January 10, 1911.

JAN 10 1911

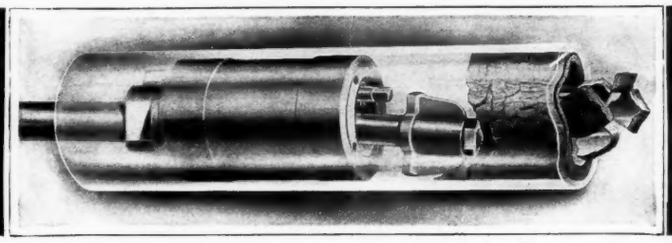
PUBLIC LIBRARY
OF THE
UNIVERSITY OF DETROIT

POWER

Issued Weekly by the Hill Publishing Company, 505 Pearl St., New York

Price 5 Cents, $2.00 per Year

Index to Advertisers Follows Reading Matter



The Dean Removing Scale from the Tube of a Water Tube Boiler.

Good Reasons For Using The Dean Boiler Tube Cleaner

Because it's two cleaners in one—water tube and fire tube. Great saving if you've got both types. All you have to do is to change the vibrator head.

Because it's operated by air or steam. No slush. Low water pressure never enters your list of troubles.

Because it removes soot and scale in the same operation. Soot is as bad as scale sometimes—oftentimes as hard to remove.

Because it removes scale clear down to the wall of the tube. Thorough work means better steaming, no more shut-downs to reroll and replace tubes, smaller coal consumption—economy.

Because it's the most durable cleaner on the market. Few working parts—one wearing part and that inexpensive.

Because there are more of them in use than any other make. Good sign that it has made good for others and can for you.

Because it is guaranteed to pay for itself in six months' use; otherwise it may be returned and the purchase price will be refunded. An indication of the manufacturer's confidence in the tool—a hint that you are now wasting money.

Where in the wide world can you find a tube cleaner backed up with so many good reasons for using it?

Our Offer

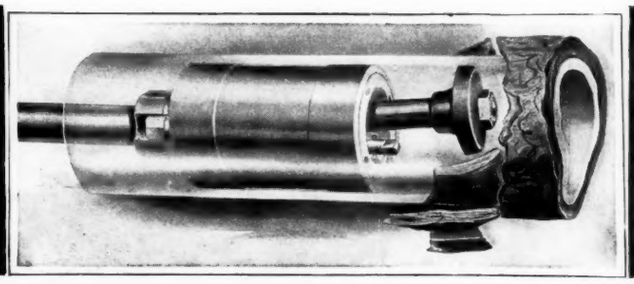
Let us send you a Dean for free trial in one boiler.
You will incur no obligations to purchase by trying it.
You are to judge its merits yourself.
If you don't like it return it at our expense.

Write for Booklet No. 130, anyway.

The Wm. B. Pierce Company

CHICAGO OFFICE
1201 Monadnock Building

Jewett Building, Buffalo, N. Y.



The Dean Removing Scale from the Tube of a Return Tubular Boiler.

KEYSTONE GREASE

KEYSTONE TRADE MARK REGISTERED U.S. PAT. OFF.

"OILEOSAURUS" (Lubricating Oil)

Babbitt Metal Boxes Fairly Melt In The Oileosaurus' Mouth

Visit the Menagerie of Almost Extinct Power Plant Monsters by day or by night and you will always find the keeper feeding the terrible Oileosaurus.

The Oil Beast—though caged up and far from well—is always hungry. It devours everything in sight—a habit acquired when roaming about among Power Plants.

Babbitt Metal Boxes are its favorite article of diet. It's as bad as it used to be when oil was used as a lubricant in Power Plants—the oil would run off the bearing and friction would do the rest.

It's different now that **Keystone Grease** is used Keystone stays on the bearings, reduces friction to a minimum and makes the engineer's life a pleasure.

No frictional heat is required to feed. Its original density never changes under severest conditions of speed and pressure.

It's "The World's Greatest Lubricant."

Take advantage of our trial offer and see for yourself!

KEYSTONE LUBRICATING CO.

Department B, **Philadelphia, Pa.**

Boston, 284-290 Franklin St.
New York, 1777 Broadway
New Orleans, 610-612 Chartres St.

Branch Offices and Warehouses:
Columbus, 542 Vermont Place
Chicago, 2123 Michigan Ave.
Minneapolis, Minn., 902 Lumber Exchange Bldg.

Denver, First National Bank Bldg.
San Francisco, 268 Market St.
Joplin, Missouri, 2131 Sergeant Ave.

No Connection With The Oil Trust

A SAMPLE FREE

KEYSTONE LUBRICATING CO.

Please send us a large size sample of Keystone Grease, sufficient for testing purposes, and it is thoroughly understood that no charges whatsoever will be made for this sample, and all express charges will be paid by you.

Name of bearing where sample will be tested . . . . . .
Its width . . . . . Combined horse power of engines . . . . . .
FIRM. . . . . .
Per . . . . . .
City . . . . . State . . . . . .

Dept. B—1-10-11 **CUT OUT THIS COUPON AND MAIL IT TO-DAY**

Lunkenheimer

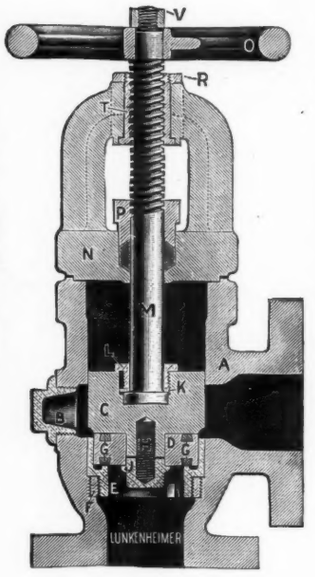
is a name
well known in the engineering field.
It is synonymous with quality

"Duro"

is a name synonymous with durability,
and which when associated with
Lunkenheimer and

Blow-off Valves

is immediately recognized by engineers
as the trade name of a valve
without an equal.



Lunkenheimer "Duro" Blow-off Valves

are guaranteed for 250 pounds working pressure The body is made of cast iron having a tensile strength of 25000 pounds per square inch. And the bronze used contains a high percentage of copper and tin.

One of the principal advantages in the design of these valves lies in the construction of the seat and disc, which provide self-cleansing seating surfaces so that any scale or grit lodging on the face of the seat will positively be washed off before the disc is firmly seated thereby insuring a perfectly tight valve.

The disc is double seated and can be reversed or renewed when worn. The seat is also renewable as are also all other parts of the valve subjected to wear.

Lunkenheimer "Duro" Blow-off Valves are made in sizes ranging from $1\frac{1}{4}$ inch to 3 inches inclusive

"MOST supply houses sell them—yours CAN—if they DONT or WONT—tell US."

A copy of our general catalog will interest you. Do you want one?

The Lunkenheimer Company

Largest manufacturers of high-grade engineering specialties in the world.

General Offices and Works, Cincinnati, Ohio, U. S. A.

—BRANCHES—

NEW YORK,
64-68 Fulton Street.

CHICAGO,
32 Dearborn Street, cor. Lake.

LONDON, S. E.
35 Great Dover Street.

2.

POWER

NEW YORK, JANUARY 10, 1911

THE comparison of our progress through life to the scaling of a ladder is a much better one than we sometimes realize.

Often the comparison is borne out in ways that we do not stop to notice. For instance, take the man whom fortune has favored with a thorough early education. When he gets into the world of business—the steam engineering field, perhaps—he has a vast advantage over another man who has been less fortunate. He easily puts below him the first few rungs of the ladder.

The rise of the less fortunate man is slow and laborious; he must grope his way up, almost blindly, wasting much time and often losing hard-gained ground in testing false rungs. At length he reaches a point where there is a gap in the ladder—one or two of the rungs are missing because of his lack of early advantages.

The first man, looking down from his higher and more secure position, is able to see clearly just what the latter's difficulty is.

If the man higher up is worthy of the name—if he is a real MAN of 45-gage construction—he will reach down his hand and give the man below the "lift" that he so badly needs.

If the man above is only a pigmy, only 22-gage, he will kick the other man in the face and shake his hold, or he will ridicule and try to discourage him.

How often such things occur your own experience shows. How many times have you needed a "hand," sometimes to be disappointed by refusal and sometimes to be surprised by the unexpected source from which the aid was given?

How many "lifts" have you given and how many withheld? Are you 45-gage or only 22?

No man can attain such a hight on the ladder of success that he can afford to ignore the appeals for assistance of those lower down. The time is likely to come any minute when he, himself, will need a "boost" from someone in a humble position. But, even allowing that he may never need further help, common decency should prompt him to do what he can to help others along, for unless he had received aid from others, undoubtedly he never could have mounted as high as he did. So, to discharge his debt to his benefactors, it is his duty to help others where and when he can.

All this applies to you, be your station high or humble.

Edward Everett Hale, now dear to memory, originated a saying which contained more than many a long sermon ever did. The sense of it is: "Look out, not in; look forward, not back; look up, not down, and lend a hand."

Power Plant of the Raike Building

By Osborn Monnett

A plant of 160 kilowatts capacity furnishing power by means of electric drive to a number of manufacturing establishments located in the building. An interesting feature of the equipment is the arrangement of the combustion arches in the boilers.

In the Louis Raike building on Jackson boulevard, Chicago, is to be found a model little steam plant of 160 kilowatts capacity which furnishes power through a system of electric drive to the various manufacturing establishments occupying the building. In a plant of this capacity, although reliability must be attained, together with a certain degree of economy, it is not justifiable to burden it with an excessive first cost for complicated and elaborate auxiliary equipment, which, although saving labor and money in a larger plant, would not justify the expenditure in one of this size where an operating force of only two is required. In the present case these features have been worked out in a satisfactory manner.

Boilers

Steam is supplied by two Brownell horizontal return-tubular boilers 66 inches in diameter by 18 feet long, having quadruple-riveted butt joints. A pressure of 139 pounds is allowed by the city-boiler inspector, but 110 pounds is the pressure usually carried. A view of the boiler room is shown in Fig. 1. Undoubtedly, the most interesting feature of the boiler setting is the arrangement of the combustion arches at the bridgewall. In the end and side elevations, Fig. 2, the arrangement of these arches is indicated. They are built of the best grade of fire tile, the two central piers, together with the side walls, permitting a triple arch at this point, the top of which closely fits the boiler shell, compelling the products of combustion to pass through the arches and breaking up the current of gases. In this type of setting the heat radiating directly from the fire is taken advantage of for making steam. It is interesting to note that, although this plant has been in operation for about twelve months, using Pocahontas coal, it has never been accused of violating the smoke ordinance. Another interesting feature of the furnace construction is the fact that the dead plates immediately in front of the fire doors can be lifted, making an opening direct to the ashpit through which ashes and clinker may be raked when the fires are being cleaned, thereby keeping all the dirt and dust in the ashpit during this operation and not on the boiler-room floor, as is ordinarily the case with hand-fired stationary grates, such as are here employed.

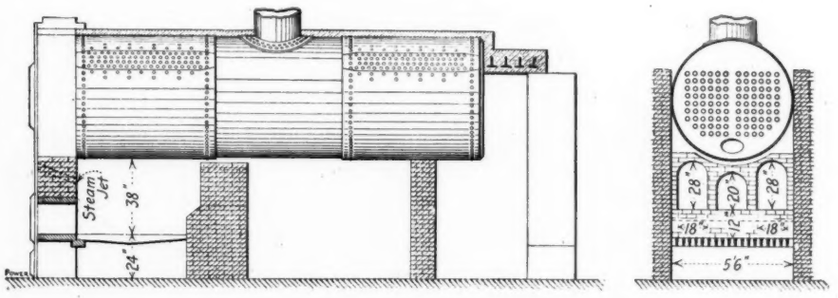


Fig. 2. Boiler and Setting, Showing Arched Bridgewall

Provision has been made for a coal-storage capacity of twenty-five tons and coal is discharged from an alley in the rear of the building either direct to the coal-storage bin or onto the passageway between the boiler room and coal-storage bin, so that in the future, if desired, a coal conveyer may be installed which will deliver the coal to a point in front of the boilers.

Piping

The steam piping is laid out on an extremely simple though efficient system. Resting directly on the rear of the boiler settings is a short 12-inch header into which 5-inch steam connections from the two boilers enter through angle valves. These steam connections are provided at the boiler nozzles with angle stop valves and nonreturn valves, all valves and piping being extra heavy with screwed flanges. From the header, long-radius bends lead to the engines, with steam separators directly above the throttles.

The 10-inch main exhaust rests in a concrete trough in the engine-room floor, covered with iron plates. This leads to a Webster open feed-water heater, first passing through an oil separator and having a connection to the exhaust-heating system. An atmospheric relief valve is also located at this point. Fig. 3 shows this part of the equipment, and also the surge tank through which water for all

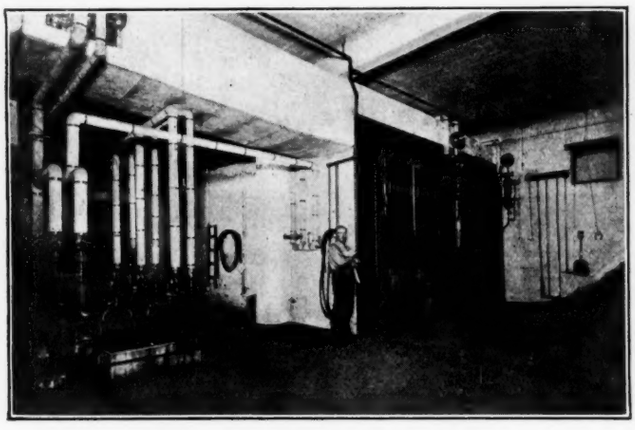


Fig. 1. Boilers and Feed Pumps

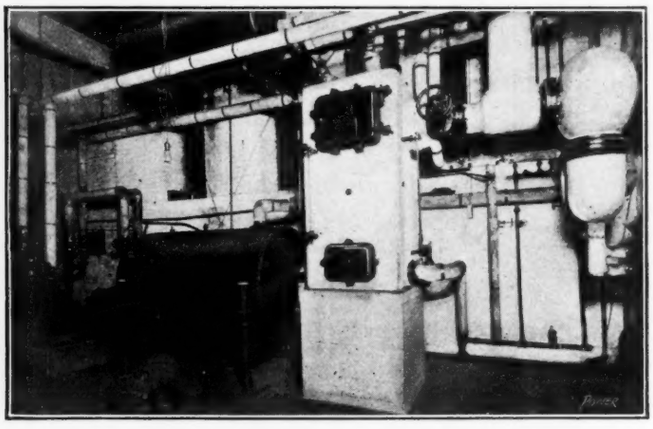


Fig. 3. Feed-water Heater, Surge Tank and Exhaust Connections

purposes enters the plant. Dearborn feed-water feeders are installed on the feed-pump suction line between the heater and the pumps. Two 6 and 4 by 6-inch Dean-of-Holyoke pumps are used for boiler-feed purposes, one always being held in reserve, and another pump of the same size is used for house service. All of these pumps are cross-connected (see Fig. 1) and may be used either for feeding the boilers or for house service. Force-feed lubricators are installed on all pumps and also on the main engines.

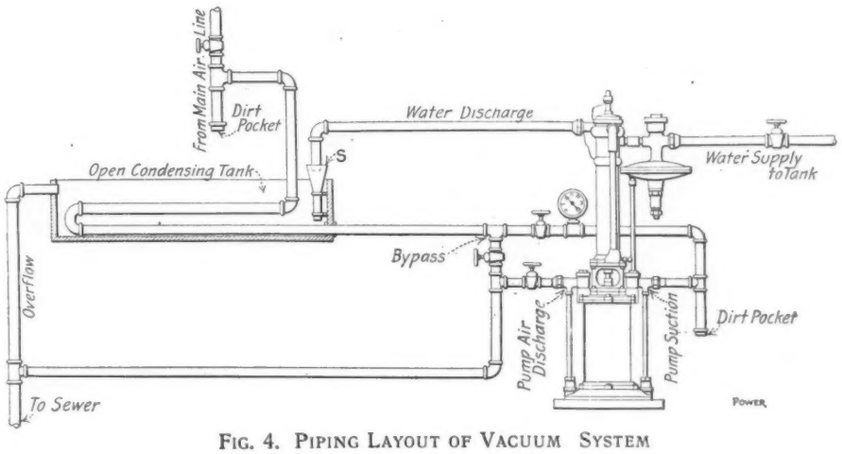


FIG. 4. PIPING LAYOUT OF VACUUM SYSTEM

The house service consists of a hot- and a cold-water supply, the latter coming direct by gravity from a tank on the roof, while the former is supplied from an auxiliary heater, using exhaust steam, but having a live-steam connection for use when necessary.

HEATING SYSTEM

The steam heating is done on the Bishop & Babcock air-line vacuum system and contains 8000 square feet of direct radiation. In this system there is a single steam-pipe connection to each radiator, and the air is removed through an automatic air valve into a vacuum maintained by a hydraulically operated pump. The operation of the vacuum pump will be apparent on reference to Fig. 4. The suction line of the pump connects with the main air line through a coil placed in an open condensing tank to which the discharge from the water cylinder of the pump is piped in such a manner that the amount of drip may be observed as shown at S. The overflow from the tank goes to the sewer. The tank is for condensing any steam that might be drawn through the air valves due to leakage or improper setting before entering the pump. A diaphragm valve is placed in the water supply and is connected to the pump suction and can be adjusted to maintain any degree of vacuum.

ENGINE ROOM

One 60-kilowatt and one 100-kilowatt Ridgway direct-connected generating units have been installed in the engine room. These are of the new Ridgway side-crank construction, but have slide valves of the single, balanced type, with a splash system of lubrication. On the acceptance tests made at the shops of the builders, they delivered a brake horsepower on slightly less than 29 pounds of steam per hour.

Fig. 5 is a view of the engine room. The decoration of the room consists of a green-painted wainscoting with cream-colored walls and ceiling. The engines are finished in green enamel with gilt trimmings and harmonize well with their surroundings. The engine-room floor, which is usually a perplexing problem when made of concrete, has been treated with a cement-floor filling, and covered with two coats of lead-colored paint, making a smooth, neat and easily cleaned surface which adds materially to the appearance of the room.

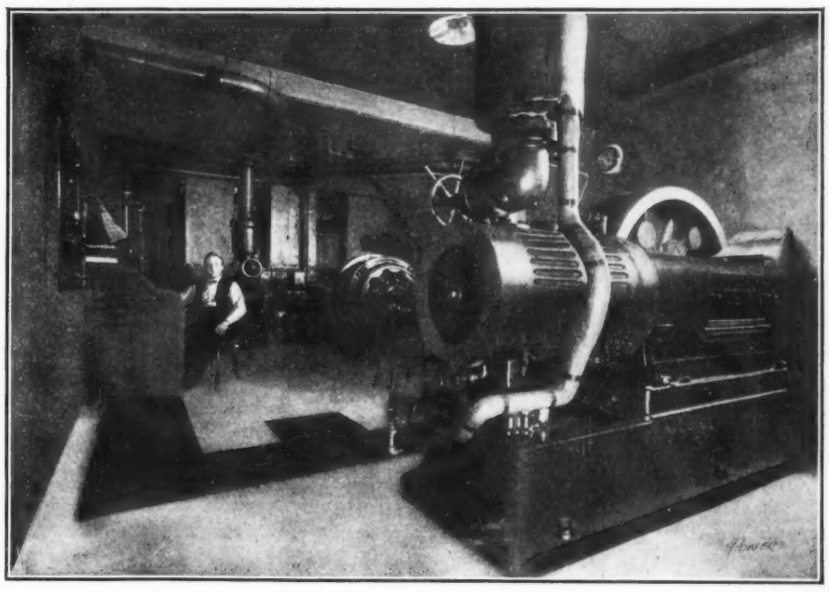


FIG. 5. GENERAL VIEW OF ENGINE ROOM

ELECTRICAL EQUIPMENT

The electrical equipment is of Thompson-Ryan make, direct current being furnished on two-wire system at 220 volts.

On the lighting circuits both tungsten and carbon-filament lamps are used; the latter are connected directly across the 220-volt circuits and the former are connected two in series, the series arrangement avoiding the necessity of using a balancer set and materially simplifying the lighting circuits. There is one light and one power circuit, the latter supplying a variety of motors ranging from ¼ to 20 horsepower. This power is metered to the various tenants and on each floor are located two cut-out panels, one for power and one for lighting.

A record transmission voltage for Europe will be established by the Lauchhammer power station in Germany, which will transmit power at 110,000 volts. The different works of Messrs. Lauchhammer, Ltd., have heretofore been supplied from separate power stations. Finding that their works at Lauchhammer were situated on a rich lignite field, it was decided to build a central power plant to supply the various works. At the same time, a central station was being planned at Gröba to supply four districts of the kingdom of Saxony. Arrangements were accordingly made to utilize, instead, the power generated at the Lauchhammer plant. Three turbo-dynamos of 5000 kilowatts each are being installed, and two more units will be added later. The current is generated at 5500 volts, and raised by means of transformers to the transmission tension of 110,000 volts. The plant will have a capacity of 40,000 kilowatts, or nearly 50,000 horsepower. —*Exchange.*

A Slowly Moving Positive Valve Gear

By Dr. Alfred Gradenwitz

Separate steam and exhaust valves of the piston type arranged tangentially to the cylinder and operated by eccentrics on a lay shaft which revolves at one-half the speed of the main shaft.

E. Frikart, of the Alsatian Machine Building Company, at Mulhouse, Germany, has designed a novel valve gear for steam engines, in connection with which the admission and outlet piston valves are arranged separately at each end of the cylinder, tangential to the latter and at right angles to its axis, being actuated through an eccentric from a side shaft which moves only at half the speed of the crank shaft of the engine, so that the opening and closing of the steam channels, with two strokes of the working piston, occur during one stroke of the valve. The steam admission is controlled immediately by a governor acting on the admission piston valve of the high-pressure cylinder.

It is well known that the increasing speeds used in connection with modern steam engines entail a positive motion, while the high steam pressures and high temperatures require the arrangement of balanced slide valves, so as to insure a smooth working of the engine. Such valves are, for instance, piston valves with self-tightening obturating rings which slide in turned boxes arranged tangentially at the ends of the cylinder. These piston valves will grind themselves of their own accord into their boxes, so as to require no special grinding. The steam distribution, owing to the large lap, is entirely insensitive in regard to end play in the outside valve gear and the waste spaces are reduced to a minimum, both in regard to their surface and volume. For the same reason an entirely positive valve gear can be used, in connection with which any spring for actuating the slide valves is dispensed with.

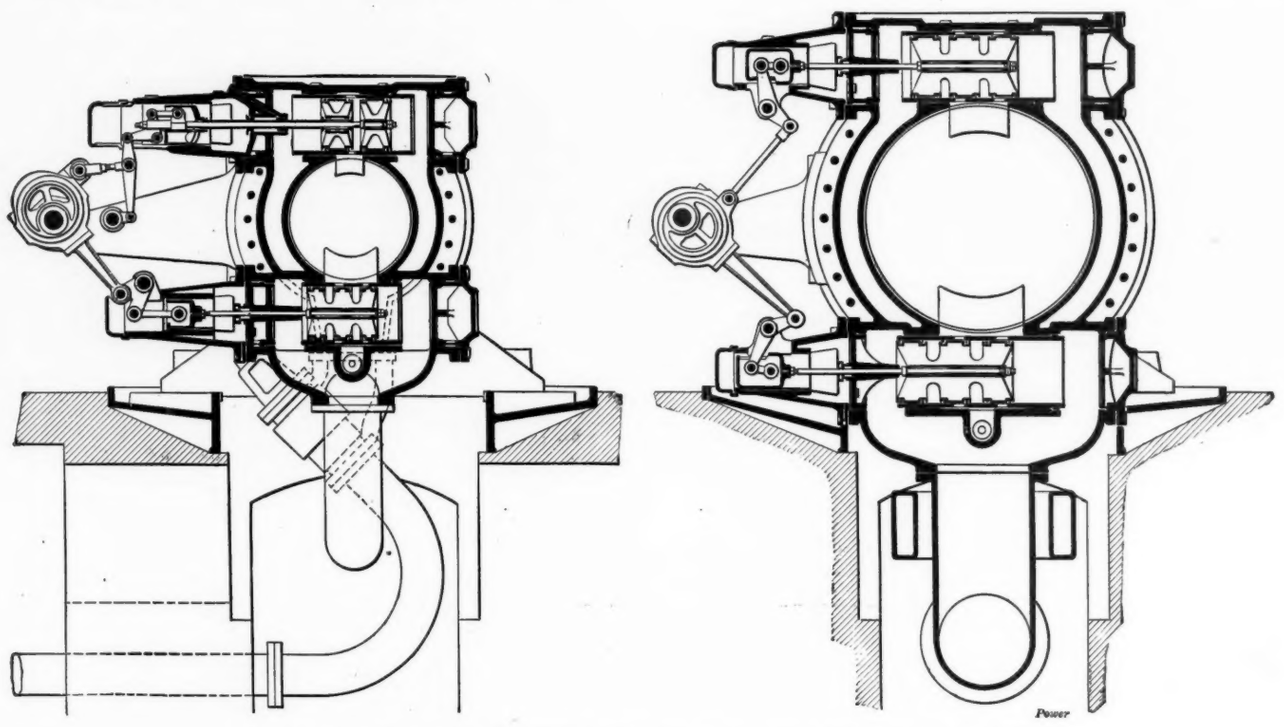


FIG. 1. CROSS-SECTIONS THROUGH VALVES OF HIGH- AND LOW-PRESSURE CYLINDERS

This advantage is utilized in a most ingenious manner in connection with the positive valve gear described herein, which works at only half the speed of the steam engine. Fig. 1 shows a cross-section through the slide valves of the high- and low-pressure cylinders of the 1000-horsepower tandem-compound engine represented in Fig. 2. Figs. 3 and 4 show the corresponding diagrams of the valve gears.

Each system of two slide valves, the upper one of which admits the steam while the lower one exhausts it from the same side of the cylinder, is operated by the same eccentric mounted on a side-shaft, parallel to the cylinder axis, which is actuated from the crank shaft through a pair of gears at a ratio of 1 to 2. Thus the eccentric turns through only 180 degrees during each full revolution of the crank, so that the admission valve operated by it moves from right to left only. The eccentric then moves an equal distance during the ensuing revolution of the crank, thus performing a full revolution of 360 degrees, and causing the slide valve to return to its initial position from the left to the right.

Each full revolution of the eccentric thus corresponds to two full revolutions of the crank, or to put it in other terms, while the piston in the cylinder changes its direction of motion twice, the slide valve makes only a single change in direction. The channels in the valve box are opened and closed by the slide valve in the following manner:

Supposing the admission slide valve in opening the channels to move from the right to the left, until the eccentric has completed its motion (corresponding to a full revolution of the crank), during the same time these channels should be opened by the slide valve, and closed again after the steam has been allowed to enter the cylinder. The opening, as represented in Fig. 3, is effected by the valve edge *e* and the closing by the edge *f*. The slide valve thus

passes by the valve port in a constant direction both in opening and closing the channels. The latter will be opened entirely when the valve apertures of equal magnitude are situated exactly between the edges of the valve port. From this moment they again begin to close.

During the next full revolution of the crank, the steam admission in regard to the cylinder will be the same. However, the eccentric now moves through 180 degrees and the slide valve, without any alteration in its direction of motion, returns to its initial position from the left to right. During this motion of the valve, the edges *f* and *e* exchange their respective positions, the former effecting the opening and the latter the closing. The valve thus actually undergoes only half the number of changes in direction as the piston itself.

On account of the manner in which the path of the eccentric is utilized for the stroke of the piston, the motion of the eccentric can be transmitted immediately to the slide valve, thus dispensing with any spring or horizontal displacement as otherwise used with a view to reducing the lap. As the slide valves both in opening and closing maintain their sense of direction unaltered, their effective opening path is determined by the circumference on the eccentric circle, intermediary between the opening and closing points, which in comparison with the whole path of the eccentric is considerably longer than the pitch of the arc between these points as otherwise used for actuating valve gears working at normal speeds.

The relation between the neighboring edges of a slide valve, and the width of the corresponding steam port in the valve box depends on the effective valve stroke for a given duration of steam admission and exhaust. Any alteration in this duration will increase or reduce the distance between these neighboring valve edges. This is how, by dividing the high-pressure admission valves into halves, Fig. 1, the steam admission to the high-pressure cylinder can be controlled, a considerable distance between the edges corresponding to a considerable admission and output of the engine, and *vice versa*. When the two halves of the slide valve come in contact so that the edges strongly strike one another, the steam admission to the cylinder is entirely discontinued.

In order to allow this valve distance to be regulated by the governor, each half of the valve is connected separately with the outside valve gear. The valve rod of the front valve is hollow, being traversed by the valve rod of the rear valve, Fig. 1, and both rods terminate in the outside valve guide box in slides connected to the gear by an angle lever, the motion of which will displace them relatively to one another, thus altering the distance between the slide valves, and accordingly the degree of admission.

As seen from the cuts, the two admission valves are actuated through a guide and a vertical lever immediately from the eccentric, the reciprocating motion of which is transmitted to the valves without altering their mutual displacement. The valves will move across the port in the box a constant distance with each piston stroke. Only when the guide, by turning the governor shaft around, lifts or lowers the vertical lever which connects the guide with the angle lever, will this distance be adjusted by the angle lever oscillating round its pivot.

The lifting of this vertical lever, as affected by adjusting the governor shaft, will increase the distance between the edges, and accordingly the duration of steam admission, while by lowering a diminution is obtained. This entails another alteration of the valve motion which is likewise of much importance for the regulation of the engine. Any alteration in the distance between the valve edges would in fact alter not only the

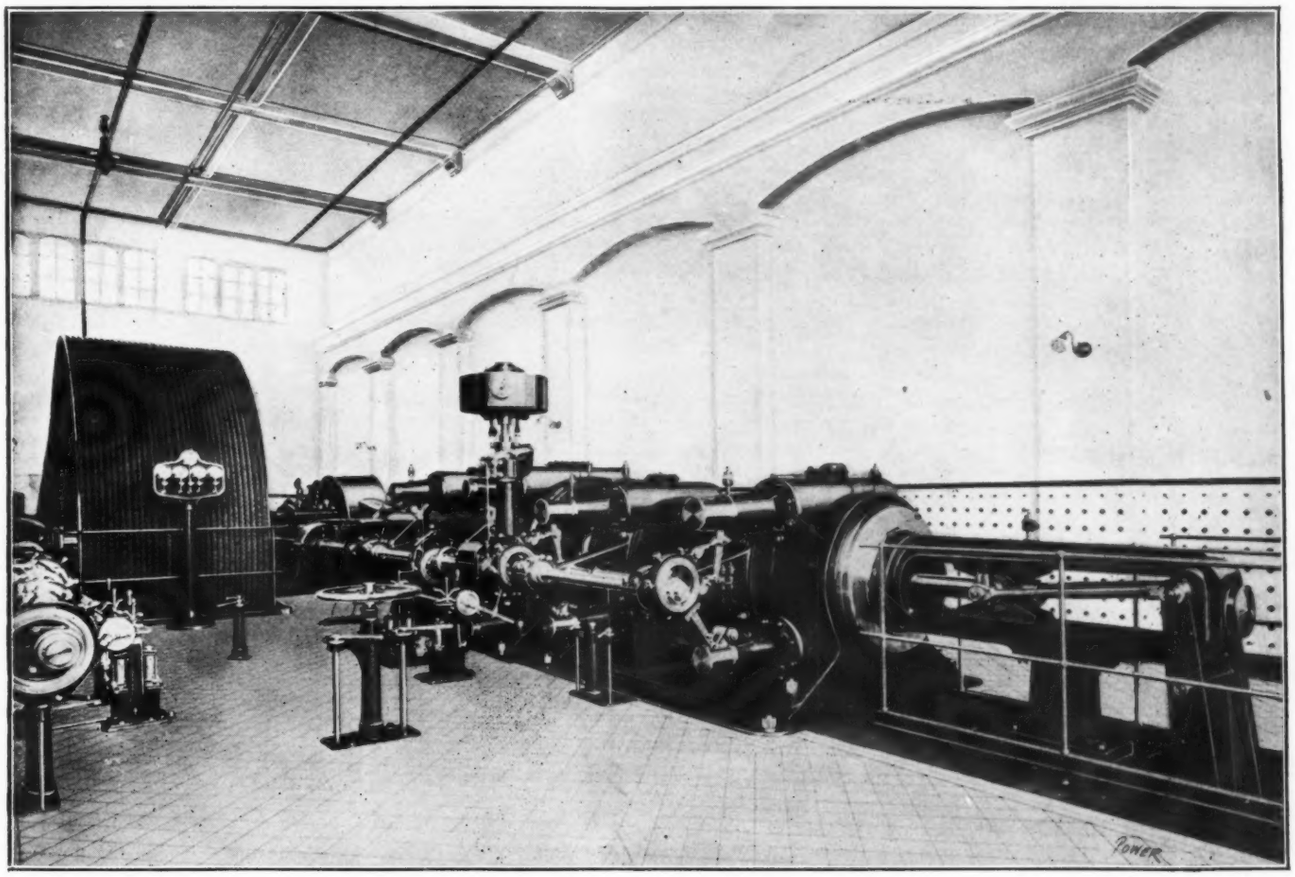


FIG. 2. 1000-HORSEPOWER TANDEM-COMPOUND ENGINE WITH FRIKART VALVES

duration of steam admission, but the admission lead as well, an increase corresponding to a considerable admission, and a decrease to a small one. In order to prevent this the governor shaft by the action of the vertical lever raises the guide of the eccentric into a given position, corresponding to a constant advance in regard to the eccentric curve. In spite of any alteration in the distance of the edges, as adjusted by the governor to the duration of steam admission, the port opening thus commences always at a given point of the eccentric curve.

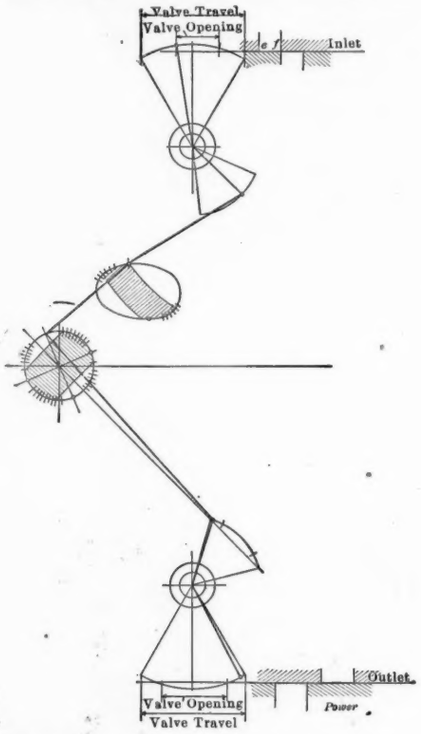


FIG. 3. DIAGRAM OF VALVE GEAR FOR HIGH-PRESSURE CYLINDER

The passage opening between the two valve edges corresponds, with any change, to a given ratio between the steam and piston speeds, so that even with the higher position of the governor, no throttling is noticed in the entering steam. As the piston valve is balanced while its frictional resistance, like those of valve rods moving in metal stuffing boxes, is quite immaterial, the reaction on the governor is extremely slight, and owing to the absence of any spring actuating the slide valves, practically constant.

This half-speed valve gear is specially adapted for high-speed engines to which an entirely smooth running and increased efficiency are insured by the positive motion. As the slide valves are arranged tangential to the cylinder, no attention need be paid to the valve gear, all the parts of which are visible and accessible during the mounting and unmounting of the piston.

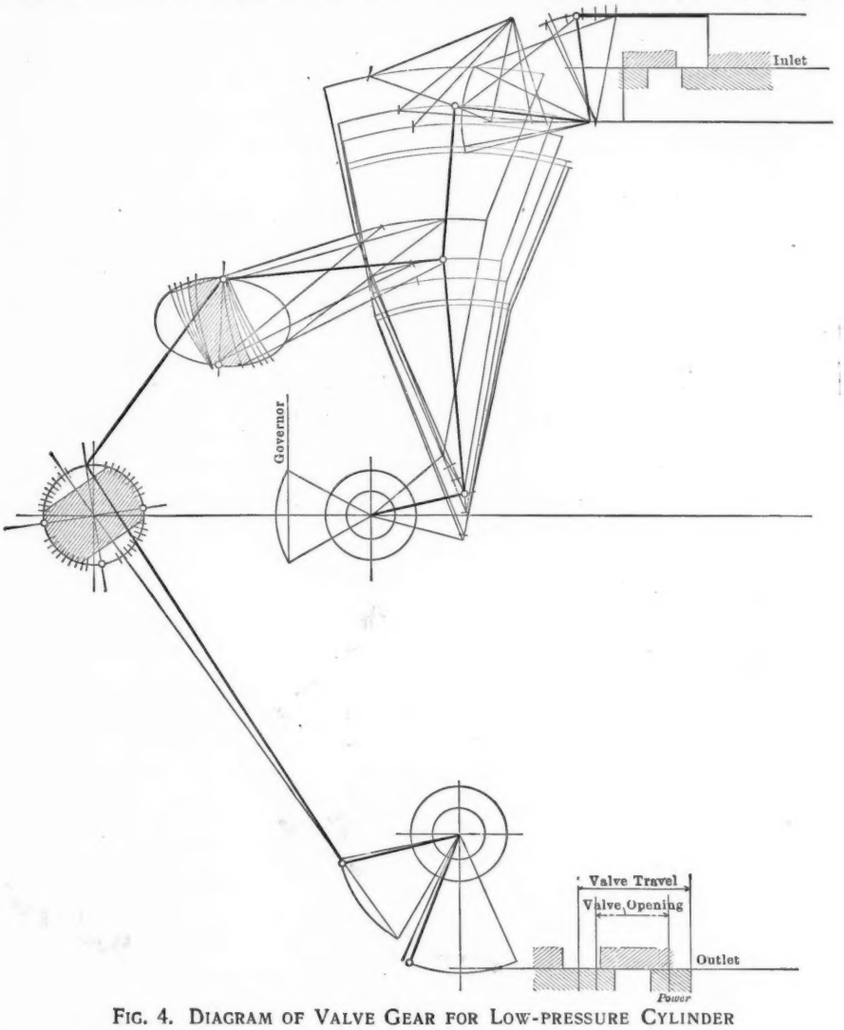


FIG. 4. DIAGRAM OF VALVE GEAR FOR LOW-PRESSURE CYLINDER

Water Hammer and Boiler Explosions

By A. Vincent Clark

Theories of cause of boiler explosions in which water hammer and the sudden liberation of large quantities of steam resulting from quick opening of a valve explain violence of some explosions.

In a previous issue a correspondent asked, "If water hammer is possible when a master valve is opened, even with haste, why is it not present with all of its alleged destructive effects every time that the safety valve blows?"

It is generally accepted that these two cases are not analogous. It must be borne in mind that the following explanations are theories, for it is practically impossible to obtain definite proof of the actual phenomena which occur when water hammer is set up or when a boiler or a steam pipe bursts. These theories, however, are the ones most easily reconcilable to the facts of the occurrences.

It is with explosions similar to that which recently occurred at Canton, where an apparently sound boiler exploded from a cause which could not definitely be ascertained, that these theories help toward a solution; it must be admitted that an engineer faces one of the most difficult tasks in his profession when he is called upon to give the cause of such an explosion, and there is not a subject upon which greater diversity of opinions is held by experts.

Water hammer in steam pipes is not an uncommon occurrence; it more often occurs when turning on steam to a line of piping, and its presence can be guaranteed if the steam is turned on too quickly; but it will also occasionally occur in pipes which have been conveying steam for some time; however, it is held by many engineers that this latter case

is completely overcome if the steam-pipe line is arranged so that it has a continuous fall from the boiler-stop valve to the engine, with no sharp bends, and with all branches provided with a stop valve close to the pipe, or the branches efficiently drained.

In the only case with which the writer has had experience this opinion was found to be justified, for a most unmanageable water hammer, which occasionally occurred even when the main engine was running with a steady load, was completely cured by providing efficient traps for all of the branches of the steam line.

In all cases of water hammer the pipes are subjected to severe shocks, and when it is very violent, such as is caused by rapidly turning on steam, a broken stop valve or a burst pipe is the result.

There are two explanations of the phenomena which occur in this case which receive general acceptance: One is, that water lying in the pipe is caught up by the incoming steam and is blown like a shot until it is brought up by the end of the pipe or by the stop valve; the other is, that steam coming into contact with the cold water lying in the pipe is suddenly condensed, thus producing a vacuum into which this steam and water are projected with explosive force.

It will be seen that these two theories can account for all of the accidents due to water hammer, and it can be realized how important it is that the velocity of the steam first entering the pipe should be very low; for the attainment of this low velocity the boiler stop valve should be opened very slowly.

There is also another reason why the sudden opening of the boiler-stop valve is dangerous for the steam-pipe line; it is well known that a safety valve often discharges as much water as steam. The action of opening the stop valve quickly is exactly similar to the opening of the safety valve; therefore, it is quite probable that, by opening the stop valve quickly, water from the boiler enters the steam pipe at a high velocity and is shot along the pipe until it is brought up by the end of the pipe, thus causing a very violent water hammer.

Nearly fifty years ago, D. K. Clark and Zerah Colborn advanced a theory regarding the violence of boiler explosions which, even now, is the best that we have and receives a general, although qualified, acceptance.

They held that in violent explosions the breaking up of the boiler is due to water being driven with great violence against the shell by the steam formed under the surface of the water directly the pressure is relieved.

It is admitted that this theory explains many of the violent explosions, but there are some exceptional cases which cannot be satisfactorily explained by it.

Taking cases of boiler explosions due to the corrosion of the plates, it may be assumed that in the case of the violent explosions the plates suddenly gave way, thus immediately allowing a great reduction of pressure and, consequently, the very rapid production of a large volume of steam, whereas in the case of the less violent explosions the initial fracture of the plate might be small and simply produce an effect very similar to that of the opening of the safety valve, and the extension of the fracture be produced during the escape of the steam and water.

This explanation is probably correct, as it is well known that the intensity of any explosion is dependent upon the time; it, however, is only applicable to cases where the boilers gave way due to the weakness of their plates, and these are not a large proportion of the violent explosions.

Some explosions have been attributed to the steam generated by the pumping of cold water into a boiler when its flues have been overheated due to the water level getting low; in such cases, unless the flues are weakened by the overheating or by being bulged, it is difficult to conceive how a boiler can explode, for, when the mass of metal and the specific heats of the substances involved are taken into account, it may be definitely said that the red-hot flues would not generate more steam than the safety valve would carry off.

The probable result of the overheating would only be leaky seams and rivets, if, as is assumed, the strength of the boiler is not affected, and it seems that unless an inspection reveals signs of this the cause of the explosion must be sought elsewhere.

Another theory regarding the violence of boiler explosions and also their probable cause has been advanced from Professor Deluc's observations of the effect of absorbed air upon the boiling point of water. He found that water entirely freed from air by ebullition could be raised to 112 degrees Centigrade without boiling, but when it boils it does so with almost explosive violence. Boiled-out water covered with a layer of oil can be raised to 120 degrees Centigrade without boiling, but above that temperature it suddenly begins to boil violently.

If this phenomenon is possible with water at atmospheric pressure then its occurrence should be possible when the water is under pressure in a boiler, and, if so, almost the ideal conditions for D. K. Clark's theory are attained, for the water next the flues would, without doubt, boil first and the water above it would be driven violently against the shell of the boiler.

A somewhat similar theory has been evolved from the knowledge that water will become spheroidal if there is a defective circulation, in this case there exists a film of steam between the water and the plates and, due to the retarded transmission of heat, the temperature of the latter will be increased; if the circulation of the water be now improved by suddenly reducing the pressure, by opening the stop valve or the safety valve, then the water coming in contact with the plates is rapidly evaporated and the steam thus formed drives the water above it violently against the boiler shell.

The last two cases are not at all similar to the one preceding them, for in that case there is no water above the steam that is rapidly generated by the overheated flue.

It is well known that it is extremely dangerous to suddenly connect a boiler to a live-steam main if there is a difference of pressure between the boiler and the main, and it is held by many engineers to be equally as dangerous to connect a boiler to a steam main quickly even if it is definitely known that the pressures are exactly the same in both cases.

Unless certain conditions are present, it is very difficult to conceive why this should be so dangerous, for in itself the connection of two boilers at exactly the same pressure should be a safe proceeding however quickly it is carried out; even if the two boilers were not at exactly the same pressure it is difficult to see that anything other than the equalizing of the pressures would occur.

The branch from the stop valve to the main is usually not in the path of the steam from the other boiler and it is quite probable that condensation would occur in this branch, so it may easily be conceived that there may be an accumulation of water above the stop valve to be opened; by remembering one of the theories of the cause of water hammer it can be seen that these are just the conditions necessary to produce an explosion when the stop valve is suddenly opened. The steam from the boiler at once comes into contact with the water and becomes suddenly condensed, a vacuum is thus formed into which the steam and water are projected with explosive force; now, if the pressure in the main is higher than the pressure in the boiler, it is certain that the water which was above the stop valve would be driven violently into the boiler and might easily be the cause of an explosion.

Experience has reduced the making of boilers to almost a science, and when the lessons of experience are learned as thoroughly by the operators then boiler explosions will be less common; an examination of the records of explosions shows that very rarely is the design of the boilers at fault, and that far too often the want of adequate inspection, or the want of care in the operation, of the boilers is the cause of the explosions which are occurring on an average of nearly two a day in this country.

The Steam Turbine in Germany

By F. E. Junge and E. Heinrich

For high economy at competitive prices a Curtis wheel in the high-pressure part, utilizing about one-third of the available energy, and Rateau wheels in the low-pressure part is the construction adopted as standard by the great majority of German builders of impulse turbines.

Rateau Wheels

The distribution of the whole drop of energy over the single stages is performed in various ways. Of importance is the consideration of the critical-pressure ratio (1.83 for superheated and 1.73 for saturated steam), a limit which one does not like to surpass as long as guiding apparatus with parallel walls are employed, though, today, the necessity of competing with other makes forces the designer, by decreasing the number of stages, to reduce the floor space of turbines, thereby lowering also the cost per horsepower. Thus it often becomes necessary to go beyond the above-named limit of critical-pressure ratio, especially in the last stages of turbines. Often a lower drop of energy is employed in the first stage in order to diminish the windage and friction work of the first wheel and to get as low pressures as possible upon the stuffing box.

Generally speaking, it is customary to divide the total drop of energy in such a way as to attain as far as possible equal outputs for each stage; that is to say, the effective velocities of issue from the guiding apparatus of each stage are then the same. In the case before us we have attempted to attain this condition for the sake of simplicity. In view of the fact that the sum of the respective energy drops of each stage becomes somewhat greater than the total theoretical drop of energy on account of the reheating of the steam—by the influence or rather influx of the heat caused by the losses—and further, in view of the other fact that to the energy drop of the second and third stages is added the exit energy $\frac{c_2^2}{2g}$ from the preceding stage, we have determined the energy drop in the single stages by way of experimentation.

Fig. 17 shows the Mollier diagram containing all the values of the steam in the various stages. Thus for the first stage the heat drop is found to be 52.2 B.t.u. Fig. 18 shows the velocity diagram.

The theoretical velocity of the steam leaving the first stage is

$$c_0 = 223.8\sqrt{52.2} = 1618 \text{ feet per second}$$

The effective velocity of issue

$$c_1 = 1618 \times 0.95 = 1537 \text{ feet per second.}$$

The circumferential velocity, as determined above, is $N = 515$ feet per second. By completing the entrance triangle we get w_1, while coefficient ψ, from Fig. 12, for a blade angle of 24 equals 0.82. Hence, $w_2 = 0.82\ w_1$, and by completing the exit triangle, $c_2 = 442$ feet per second.

Thus we get from equation 9 (January 3)

$$M = 0.6\frac{442^2}{2g \times 778} = 2.3 \text{ B.t.u.}$$

The energy drop of the following stages we take as 49.9 B.t.u. and get as the energy of the steam issuing again 49.9 + 2.3 = 52.2 B.t.u. The same result is attained in the third stage. As was said, this accordance of the velocities of issue and therefore of the outputs of the various stages cannot be quite exactly figured out beforehand, but must be found out by trial, more or less.

The indicated efficiency is found from the diagram to be

$$\eta i = \frac{2.515\ (1485 + 272)}{1618^2} = 0.69$$

hence,

$$R = (1 - 0.69)\ 52.2 = 16.2.$$

The windages are determined with the assumption of a mean admission diameter of $D = 3.28$ feet, and a mean blade length of ½ inch = 0.0416 foot. The specific volumes v and thereby the specific weights $\gamma = \frac{1}{v}$ are found from the Mollier diagram.

The losses through leakage on the wheel hubs were determined from equation 7 under the assumption $d_0 = 190$ mm. = 0.624 feet, $s = 0.3$ mm. = 0.000985

Stage.	1	2	3
1.) R	16.2	16.2	16.2
2.) $\frac{V}{g}$	4.4	2.8	1.7
3.) $\eta_i h_0 \frac{g_0}{g}$	....	1.9	1.1
4.) M	2.3	2.3	2.3
$L = 1 + 2 + 3 - 4$	18.3	18.6	16.7
Converted energy	52.2	49.9	49.9
Utilized energy	33.9	31.3	33.2

feet (see Fig. 11), which corresponds to conditions as they obtain in actual practice. The results of the calculation of losses have been assembled in the accompanying table, the sum of losses being composed according to equation 11. The energy utilized in each stage is obtained as the difference of the converted energy and of the losses. (All amounts of loss in the accompanying table are expressed in B.t.u.)

From this table the total amount of utilized energy is obtained as

$$He = 33.9 + 31.2 + 33.2 = 98.3$$

Therefore the internal efficiency of the Rateau stages:

$$\eta = \frac{98.3}{146} = 67.4 \text{ per cent.}$$

With the assumptions upon which we have based this calculation the thermal efficiency of the Curtis wheel is 64.4 per cent. and that of the Rateau wheels 67.4 per cent. As far as heat economy is concerned the Rateau wheels for the size of turbine in question appear therefore superior.

Additional Losses

To the above losses as determined by calculation is to be added a comparatively small amount of such losses, the heat of which does not reënter the steam but is carried off through conduction and radiation one way or another. These losses are: (*a*) the external mechanical losses through friction of bearings and stuffing boxes, as well as by the work which is consumed for operating governor and oil pumps; (*b*) the steam losses through the high-pressure stuffing box and other leakages; (*c*) the losses through radiation of the casing.

We note that the sum of these additional losses amounts for the size of turbines considered to some 10 per cent. of the total losses, which is about 3 per cent. of the total capacity of the turbine. Concerning loss *a*, both systems are on a par. As to the losses *b* and *c*, the Curtis system is somewhat superior, because it employs lower pressures and temperatures in the casing. Thus in consideration of these losses the comparison comes out somewhat more favorable for the Curtis wheel, more favorable at least than the above numeric result would imply. Yet, in view of the comparatively small amount of additional losses, the Rateau wheel after all appears undoubtedly superior.

Influence of Size of Turbine

So far we have only dealt with the high-pressure part of a turbine of 1000 kilowatts capacity. Considering equation 11 for the losses

$$L = (1 - \eta_i)\, h_o + \frac{g_o}{g}\, \eta_i\, h_o + \frac{y}{q} - M$$

we find the amount

$$l = \frac{g_o}{g}\, \eta_i\, h_o$$

which occurs only with Rateau wheels, grows smaller with increasing steam weight g and therefore with increasing output of the turbine, provided that all the dimensions remain the same and only the cross-section of steam flow is enlarged. That is to say, with increasing output the efficiency of the Rateau wheels increases and therefore the superiority of the Rateau over the Curtis type. On the other hand, with decreasing capacity of turbines the influence of the leakage losses of Rateau wheels will be more pronounced and the Curtis wheel appears more advantageous.

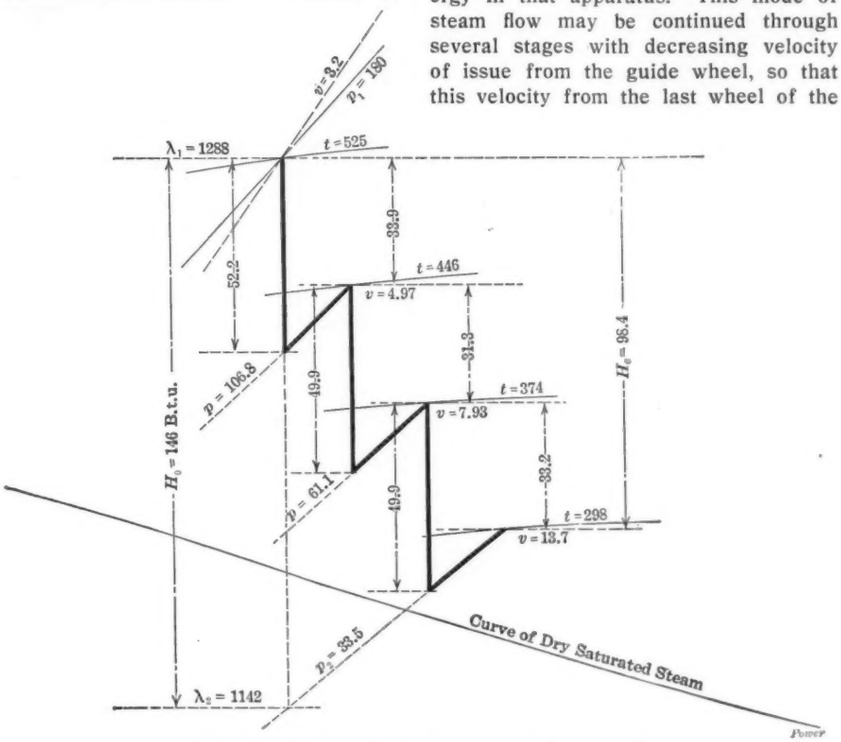


FIG. 17. MOLLIER DIAGRAM OF THE RATEAU WHEELS

COMBINATION OF CURTIS AND RATEAU PRINCIPLES

Some designers, who apply the constructive principles of Rateau and Zoelly according to Fig. 14, have adopted the Curtis principle as far as the flow of steam is concerned. They use the following mode of design: In order to expand down to lower pressure immediately with a view to keeping the windage of the first wheel and the losses through the high-pressure stuffing box as low as possible they provide in the first stage a high steam velocity by using conically diverging nozzles. In this case the velocity of issue from the first revolving wheel is still considerable and must be utilized in the following guiding apparatus to the highest possible extent. But in contradistinction to the pure Curtis principle a certain amount of heat is at the same time converted in the second guiding apparatus.

One expects from this conversion in the second guiding apparatus a better avoiding of losses by whirling than is possible without transformation of energy in that apparatus. This mode of steam flow may be continued through several stages with decreasing velocity of issue from the guide wheel, so that this velocity from the last wheel of the group is very low. Thus the ultimate loss of energy of issue is kept comparatively small.

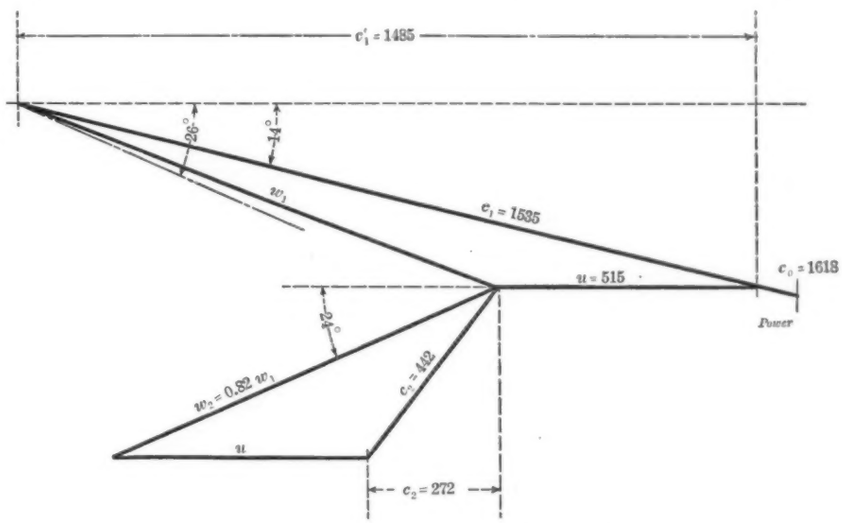


FIG. 18. VELOCITY DIAGRAM OF THE RATEAU WHEELS

This system affords a combination of velocity and pressure stages which, however, in our notion does not offer tangible advantages. It possesses the constructive features of the Rateau type, having the disadvantage of higher weight and higher initial cost of building, while as an advantage is claimed a good economy. But the latter can only be attained with very careful design of the guiding apparatus and equipment with limit blades or, what we call "profiled blades," which, of course, augments the first cost against the pure Rateau type, provided that both have the same number of stages.

RÉSUMÉ

Summing up the results of our investigation we may say: At the present state of the art of steam-turbine building it appears unreasonable to point to any one system of steam turbine as the one best fitted for all sizes and conditions. There are questions of size, first cost, fuel economy and operation which should determine the selection of the system. Generally speaking, one may say that the Curtis system is superior for the smaller sizes of stationary turbines, as regards heat economy and first cost, while for the larger sizes the Rateau system, certainly in the low-pressure part, is superior in heat economy. Yet even in the larger sizes the somewhat cheaper cost of construction, lower weight and smaller floor space may swing the decision in favor of the Curtis type. In the case which we have considered above, high-pressure part of a turbine of 100 kilowatts capacity, the Rateau system apparently is more advantageous as far as heat economy is concerned. All points considered, the arrangement: Curtis wheel in the high-pressure part, utilizing about one-third of the available energy, Rateau wheels in the low-pressure part, utilizing about two-thirds of the available energy, which is now being adopted by the overwhelming majority of German builders of impulse turbines as standard construction for a wide range of outputs, appears justified for stationary practice whenever conditions demand high economy at competitive prices.

Device for Preventing Smoke

By W. H. Odell

Some of the excess air in the flue gases is drawn from the breeching by means of a jet of superheated steam and directed into the combustion chamber. This hot blast aids in the combustion of the particles which would otherwise escape up the stack unburned.

Much has been written and many devices used in the hope of finding some practical method of burning bituminous coal in steam boilers without producing an undue amount of smoke, but, because of the numerous failures, the problem is looked upon by many mill and factory owners as a joke. There are many arrangements of furnaces on the market at present that accomplish the desired result if properly handled, but the great drawback is their excessive first cost and lack of durability. However, there is a method by which at small first cost any mechanic can equip a horizontal tubular boiler having a flush front in such a manner that with proper care the results will equal if not surpass the expensive outfits installed in many large plants.

The immediate cause that led to the construction of this device was the fact that some years ago a large manufacturing company had been induced to buy a cargo of 500 tons of Nova Scotia coal, and if there is anything that can beat it as a smoke producer, I have yet to learn what it is. I was called upon to devise a means for overcoming the difficulty and accordingly installed practically the same device as here shown, except that there was no coil in the breeching to superheat the steam, and cold air was taken in from the fire-room floor and fed in through the jets, whereas in the system herein described the air is drawn in from the breeching at a temperature which averages about 600 degrees Fahrenheit and there is always enough oxygen in the uptake to support combustion. This has been proved repeatedly in some of my later installations by closing the ashpit doors, and opening only the fire doors when feeding the furnace.

Some years ago an inventor made the claim, and apparently proved that there were two currents of air in a smokestack, the heated air or gases ascending the center of the stack while a thin film of cooler aid descended at the outer edge of the stack, and my experience with the ashpit doors closed seemed to confirm this theory.

I have never tried this device for economy with bituminous coal, but have tried it with anthracite coal and found a gain of about 6 per cent. when supplying the furnace with the heated air. The steam consumed by the device is about 1 per cent. of the total steam generated by the boiler.

As shown by Fig. 1, three small cast-iron boxes open at two sides are placed in the bottom of the uptake and are connected to the superheating coil in such a way that the jets of heated air and steam can readily be directed at any desired angle, although the best practice seems to be to direct them at an angle to meet the junction of the grate bars with the bridgewall. An enlarged view of the steam jet is shown in Fig. 2 in order that its construction may be more readily understood. These jets are of cast brass about four inches long with a ½-inch pipe thread cut on the outside, well down so that adjustments can be made if desired and then fixed by means of a locknut. The connection to the steam jet is made with a ½-inch tee in one end of which is a plug; this is to permit the insertion of a wire for removing any obstruction that might get into the jet.

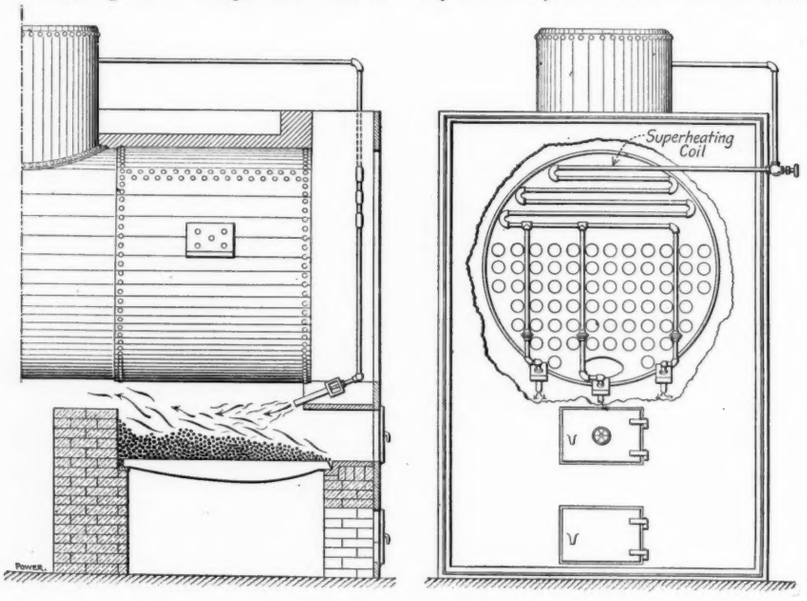


FIG. 1. COIL IN PLACE

This device was patented during 1880 but as the life of the patent ran out many years ago there is nothing to prevent anyone from using it. I did not make any serious effort to put this device on the market because of the fact that about the time it was perfected I became engaged in other work which was more pressing; but as an object lesson to some young engineers it may be of interest to relate some of my experiences with it, as they show what many inventors have to contend with.

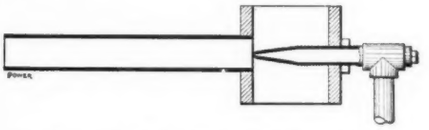


FIG. 2. SECTION THROUGH JET

At the plant for which this device was gotten up there were six horizontal-tubular boilers, and as the service required only five of the boilers, it was arranged that I should have the spare boiler upon which to experiment. I took the precaution to insert a piece of 2-inch pipe through the back wall of the boiler setting about 6 inches below the bottom of the shell and as the outer end of this pipe was covered with glass we had a convenient peep hole without admitting any air.

When all was ready the five boilers were fired with anthracite coal, leaving the spare boiler to be fired with bituminous coal. Previous to cutting in with the hot blast at every firing a volume of dense black smoke would issue from the top of the stack and would continue for several minutes.

When one of the partners of the firm reached the factory about 9 o'clock, he immediately came to the fire room and began to upbraid me, saying he had been watching the top of the stack all morning and there was as much smoke as when all the boilers were fired with soft coal. I replied that my device had not been tried as yet and that I wanted him present when it was turned on for the first time. Then I asked him to take his station at the peep hole; a heavy charge of coal was put on the grates, the fire door was closed and nothing could be seen through the peep hole except an occasional tongue of flame showing dimly through the smoke. However, the

instant the hot blast was turned on the effect was as if a gas jet had been lighted in a dark room.

In about a minute the blast was shut off and the smoke appeared again at the top of the stack, apparently as dense as ever. We made this change from dense smoke to no smoke at all, four times before this first charge of coal was of no further use to us.

Leaving the device for a few days that it might be tried out to the full satisfaction of the factory owners as well as any of their interested employees, I finally called on them for the $75 which had been promised if the device were a success, also to learn when it would be convenient to have their other five boilers fitted in a similar manner; but this time I met with the other partner, who, in this case, was also the purchasing agent, and who assured me that their engineer had told them he could fit the remaining boilers up for about $35 each. I admitted that this was approximately the cost of the material used and as they would not have to pay anything extra for the engineer's services it could probably be done at the figure named, but reminded him of our agreement. He replied that he did not care about the agreement, and as I had not made any move toward patenting my invention at that time I could do nothing but order my helpers to take the device out.

My second experience at smoke prevention was while representing a boiler manufacturer at the cotton exposition at Atlanta, Ga. I there met a couple of young fellows who owned a small cotton mill at Selma. They had heard of this device and wanted me to install it on their two boilers as they were greatly annoyed by soot and smoke. My engagements at the exposition prevented, but in order to help them out I made drawings, told them to go ahead and install it themselves and if after three months' trial it proved satisfactory they could send me their check for $25. I did not hear from them until several months later when I received a letter saying my device made such a hot fire that it had burned their boilers and they wanted me to pay the bill.

Notwithstanding these experiences, this simple device which any ordinary workman can install in a few hours is one of the most efficient yet produced, and much of its efficiency depends upon the use of the heated air.

Notes on Riveting Boiler Plates

By H. S. Jeffery

Suggestions as to the proper clearance between the rivet and the hole, and the means used to upset the rivet so as to fill the hole. Methods of forming the rivet head and of obtaining a tight joint.

The first consideration in driving rivets is the pitch for a given size of rivet and a given thickness of plate. Rivet holes should be spaced close enough to permit of good calking of the seam; at the same time, they should be spaced far enough apart to give the strongest joint obtainable for a given thickness of plate. In a triple-riveted double-strapped butt joint, the outer row of rivets has a wide pitch, and in order to insure efficient calking, the outside butt strap should be heavy enough to withstand the calking without springing between the rivets.

Most boiler rules stipulate that the thickness of the butt straps shall not be less than five-eighths of the thickness of the shell plate, but with boilers having shell plates from ¼ to ½ inch, the better practice is to make the butt straps the same thickness as the shell sheet. The chief difficulty with the light butt strap is that it will spring between the rivets under the necessary calking, forming small water chambers between the sheet and the butt strap, and tending to loosen the sheet around the rivets.

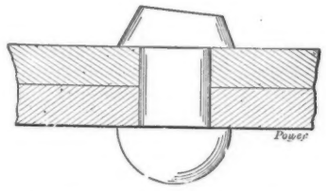


FIG. 1. INCORRECT WAY OF FORMING RIVET HEAD

It is almost universal practice to make the rivet holes 1/16 inch larger than the diameter of the rivet, the adoption of this clearance being traced back to the early days when only iron shell plates and rivets were used. With modern progress, however, the diameters of rivets are more uniform, and this, coupled with the fact that rivet holes are now drilled or reamed, permits less clearance, and some modern shops are now allowing only 1/32-inch clearance.

With hand-driven rivets, the rivets are upset from one end only, and if the clearance between the rivet and the hole is large and the rivet passes through several thicknesses of plate, the rivet will not be upset its entire length so as to fill the hole completely. This, together with the scale which every rivet has to a greater or lesser degree, causes rivets to leak under the breathing of the boiler. The main consideration in order to have steam-tight rivets is to fill the rivet holes. The rivets should be hit heavy blows for the purpose of upsetting them their entire length, if possible. Knocking the rivets with light hammers results in upsetting the rivet only a short distance, as that part of the rivet which should be driven into the hole is not forced there by the use of light hammers; and, therefore, becomes a part of the rivet head, which becomes larger than intended. Some boilermakers, when the rivets are too short for the upset and the head, upset the rivets so as to have sufficient metal for the rivet head, regardless of how the hole is filled.

Snap riveting, in which the rivet head is formed with a cup-shaped rivet set by striking the set several blows from steel mauls, is usually handled by knocking the rivet down with the same mauls as used for striking the rivet set. With this kind of riveting the rivet usually projects beyond the hole considerably more than with hand riveting, and the heavy blows delivered by the mauls upset the rivet a greater length. The set should be held erect during the formation of the rivet head, and to tuck in the edges it should also be held erect, holding the center of the set to one side of the center of the rivet and working around the

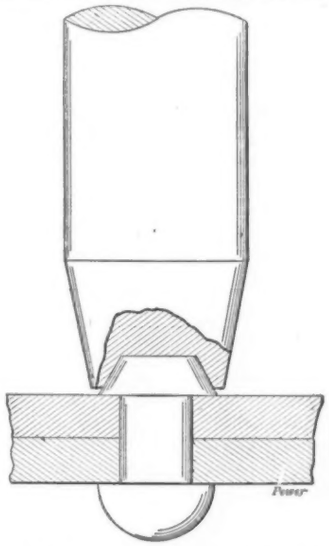


FIG. 2. CORRECT POSITION OF HOLDING-ON BAR

rivet in this manner until the entire edge is shaped. Rolling the set around the rivet, that is, tipping the set in an effort to trim the edges, usually results in a ring or recess being cut in the sheet around the rivet head, and this should by all means be avoided.

The same rules which govern snap

riveting also govern pneumatic riveting to a great extent. With hydraulic riveting, it is possible to upset the rivet from both ends, this being accomplished by converting a cone-headed rivet into a button-headed rivet. With hand, snap and pneumatic riveting, the newly formed rivet head is usually on the outside of the boiler, while with hydraulic riveting it is usually on the inside of the boiler. In the former cases the rivet hole is filled in the outer sheet, and in the latter it is filled in the inner sheet. But, by converting the rivet head as mentioned, the rivet hole is usually filled in both the inner and outer sheets.

Regardless of the manner of riveting, the sheets should be metal to metal, for, if apart, the rivet will upset and form a ridge between the sheets, which will keep them apart and also require the rivets to be longer than would be necessary if the plates were metal to metal.

The manner of holding the rivet when driving is equally as important as the manner of driving. The rivet head should at all times be well up against the sheet at all points. The holding-on bar should bear against the rivet so as to not shape the rivet head as shown in Fig. 1. With snap riveting there is a tendency for the rivet heads to crack, and to overcome this the usual practice is to cup the holding-on bar to suit the rivet head, but the depth of the cup is made from 1/8 to 3/32 inch less than the depth of the head so that the holding-on-bar will not come in contact with the plate; this is indicated in Fig. 2.

An Investigation of Bearing Metals

By H. B. McDermid

Actual conditions under which tests were made of seven different bearing metal mixtures of tin-lead-antimony and copper-tin-antimony alloys.

The choosing of his materials of construction, in the face of modern competition, often becomes a serious problem to the manufacturer of machinery, and is worthy of serious study.

The use of some 400 tons of babbitt metals per annum, by a company engaged in the manufacture of heavy power-plant prime movers, was deemed to be a sufficient reason to justify a thorough investigation of the physical properties of those metals. In consequence, a series of friction tests were carried on, of sufficient length to quite completely determine the running characteristics of a number of different mixtures.

The object of the work done was largely to determine whether or not the cost of making bearings could be reduced without lowering the factor of safety to a dangerous point.

The cost of materials for the different mixtures varied from about 7 to 33 cents per pound. In view of this fact, some of the results obtained were decidedly interesting. There are many places in modern machine construction where the designs can be made such as will permit of low unit pressures on bearing surfaces, so that a cheaper bearing metal can be safely introduced.

Cheaper Construction

In many instances, pressures now used will permit of less costly construction, especially as, in some instances, the higher-priced metals do not show as high-grade performance as some mixtures whose costs do not exceed 40 per cent. of their more costly competitors. This is markedly true of bearings running under good lubricating conditions, with the pressure constant and always in one direction, as in many forms of motor bearings, generators, steam turbines, etc.

An example of this is a 6500-kilowatt dynamo running in two bearings 14x48 inches each, where the unit pressure due to dead load is but 70 pounds per square inch, and where, being direct connected to an hydraulic turbine, the pressure is always steady and in one direction. This machine was furnished with a supposedly high-grade babbitt at a cost of some 25 cents per pound, when test results proved an 8-cent mixture to be superior in every case under those conditions, and showed it to be fully capable of carrying the load at all times, even when the magnetic pull due to an unbalanced air gap was taken into consideration.

Conditions of Tests

The tests were run, for the most part, upon a homemade machine, so arranged that any desirable load could be placed upon the test piece, which was made in the form of an upper half box, covering a full half of a 7-inch journal. The journal was carried in side bearings of ample area to insure their safely carrying all loads imposed upon them. The surface speed at the test piece was 480 feet per minute and at the side bearings 220 feet per minute.

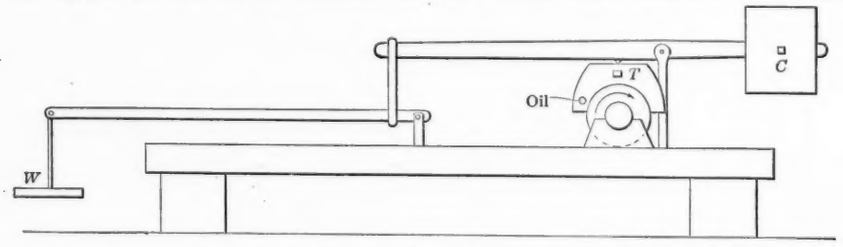


Fig. 1. The Testing Machine for Bearings

No appliance was provided for the direct measurement of the friction developed, so that the rise in temperature was taken as the only indication of the friction of the rubbing surfaces, and with cool running side bearings so that no outside error could creep in to any extent. This method was found to be amply accurate and satisfactory for the comparative tests desired.

The Test Machine and Bearings

The general arrangement of the machine is shown in Fig. 1, where *C* is an adjustable counterweight used to balance the system of levers shown, and *W* is a weight pan used for loading the test piece *T*. The ratio of the force exerted at *W* to that at *T* was 1 to 70. It was thus comparatively easy to get relatively high unit pressures on the test piece, which measured 7 inches in diameter and 2 inches long.

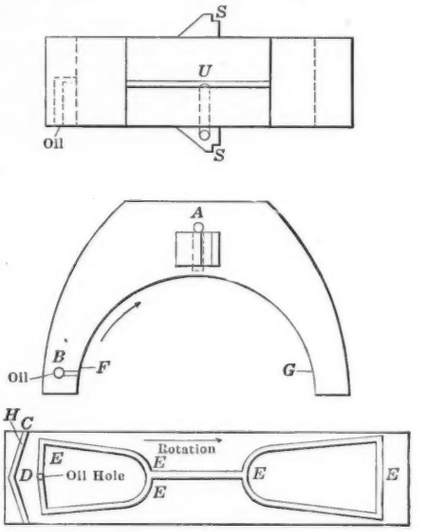


Fig. 2. The Test Bearing

A side elevation and plan, and a developed plan of the test bearings is shown in Fig. 2. Here *A* indicates a thermometer well, drilled diagonally down through the stop piece *S* which is on each side. During actual work, this stop piece rests against the frame of the machine in such

a manner as to prevent rotation about the shaft. To render the sketch clearer, this portion of the frame is not shown in Fig. 1. The thermometer well was drilled so the bulb of the instrument would rest at a point ½ inch above the bearing surface of the babbitt and in the middle of the test piece, as measured along the axis of the shaft. *B* is the place for introducing the lubricating oil, which was fed from a drop-feed oil cup during the final tests.

In the developed plan, a system of air and oil grooves is shown. These were the same for each specimen, and were cut so as to finish 3/16 inch half round in section. The air groove was found necessary in order to carry off air that was drawn in by the rapidly rotating shaft, which otherwise was forced out at *B* in quantities great enough to render uncertain if not absolutely destroy the lubricating of the piece. In order to have it in proper working condition the edges of this groove must tightly fit the journal at the inside edge *D* and be loose and free at the outer edge *H*. The mixture of air and oil that adheres to the shaft is then scraped off by edge *D* and deflected to the sides of the piece, thereby insuring undisturbed lubrication of the rubbing parts. To insure thorough spreading of the entering oil, the oil channels are well relieved at the sides *E*.

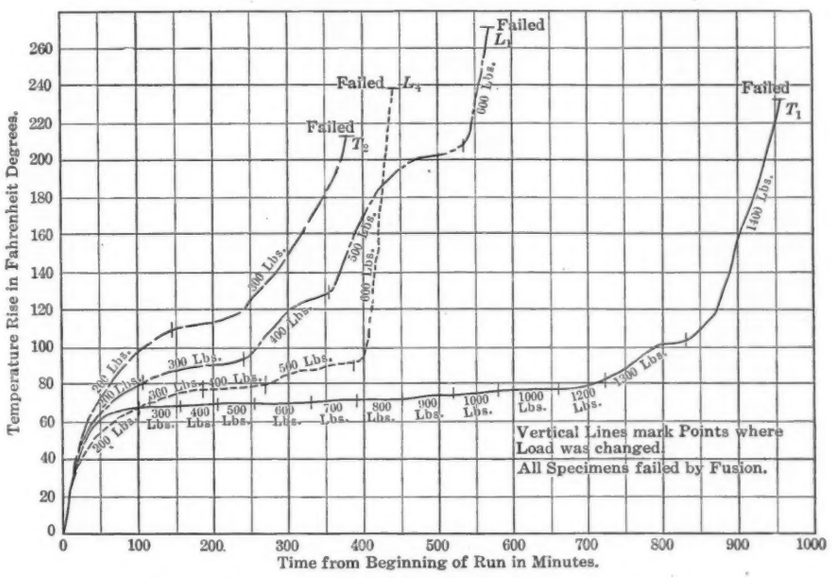


FIG. 3. AVERAGE TEST OF THE FOUR HIGHEST MIXTURES

PRECAUTIONS TAKEN

Every precaution possible was taken to insure uniform working conditions for each test piece, so that the test might be dependably accurate, at least for comparative results. It was ascertained that after minute and careful inspection two test pieces might appear exactly alike, might be of the same material, have apparently identical smoothness of glazed surface, be treated as closely alike as possible, and yet run widely different final tests.

To this end, then, the babbitt was carefully melted, in clean ladles, so no dross nor undue burning or overheating might form gritty or abrasive spots or surfaces that might cause friction and heating; the metal was carefully anchored in the shells so that it might always have solid, positive, uniform backing to transmit the heavy pressures of the system of loading levers with no springing, breaking, or pinching; it was closely bored to fit the journal, and machined to exact dimensions; and the journal was ground straight and cylindrical, so that for each piece tested, the conditions were made as nearly uniform as good mechanical skill could make them.

The test piece was fitted to the machine by placing it upon the journal and fitting the stops *S S*, until both bore equally upon their stops on the frame of the machine within the limit of 1/1000 of an inch, thus eliminating the possibility of any sort of side twist being introduced. The casting at *U* was so beveled that the load perforce had to bear vertically downward and thus eliminate all pressures not in a vertical plane passing through the center of the bearing, normal to the axis of the test journal.

By these means it was believed that reasonable accuracy in conditions had been obtained and correspondingly dependable results were secured.

PREPARING THE BEARINGS

The bearing was next "spotted in" upon the slowly revolving shaft and scraped to as close a fit as possible, the oil and air grooves were then cut and finished and the journal placed in an oil bath and run at full speed. The bearing was placed under very light loads at first and this gradually increased, as the thermometer record showed it could stand it, until the bearing possessed a perfect glazed contact with the journal from *F* to *G*, and would run at a cool uniform temperature under heavy loads.

This latter point was very important as two bearings may apparently have an equally good fit and glaze, and yet, even though of the same material, one will coolly stand up under a load that would shortly ruin the other, due to minute differences which even the closest inspection must fail to detect, and which cannot be detected except by a running test under identical conditions.

This preliminary "running in" occupied from ten to thirty hours, according to the material tested and to the care with which the preliminary and subsequent fitting had been done. During this preparatory stage the temperature was never allowed to rise above 220 degrees Fahrenheit, so the oil would not carbonize upon the rubbing surfaces under any conditions and so permanently injure them.

TABLE 1. CHEMICAL ANALYSES OF ALL MIXTURES.

Name.	Copper, Percentage.	Tin, Percentage.	Lead, Percentage.	Antimony, Percentage.	Bismuth, Percentage.
L_1	..	15	75	10	...
L_2	..	9	90	1	...
L_3	..	5	80	14.5	0.5
L_4	..	5	85	9.5	0.5
T_1	5	85	..	10	...
T_2	4	61	25	10	...
T_3	6	83	..	11	...

The run was kept up as continuously as convenient with each specimen until it would stand from 600 to 1000 pounds per square inch under oil bath conditions and still run fairly cool. The machine was then allowed to cool down over night to practically the temperature of the room, and without anything occurring that could disturb the accuracy or perfection of the fit of the rubbing surfaces of either the journal or test piece, the final test was begun.

FINAL TESTS

The following rules were closely adhered to in conducting the final tests after the specimens were fully prepared:

1. All tests to be started with the whole machine and testing system practically at the temperature of the room.
2. The oil to be a standard high-grade engine oil, with a sufficient supply on hand to permit of the whole series of tests being run with the same lubricant.
3. A standard new oil cup to be used and the oil fed upon the bearing at 45 drops per minute; the rate of feed being checked every ten minutes.
4. Each bearing to be loaded at the start, with a pressure of 200 pounds per square inch. Readings of room and bearing temperatures to be taken every five

minutes, until the temperature of the bearing became constant within two degrees Fahrenheit for three-quarters of an hour. The load then to be increased to 300 pounds per square inch with temperature readings taken as before. The load then to be increased to 400 pounds, and so on until failure occurred by fusion of the mixture under test.

5. All tests must be judged by the same thermometers. The thermometer well must be filled with oil at starting so the heat from the bearing will be readily and accurately transmitted to the bulb of the instrument.

6. Care must be taken to have all parts of the machine in proper adjustment and kept so. All other conditions must be kept as nearly standard as possible, so the working will be thoroughly reliable as a comparative test.

Duplicate Tests

After the test had been run to the finish by "failure," a process that necessarily had to be completed without interruption of any kind, and which lasted from 3 to 15 hours with varying grades of metals, the machine was dismantled, and the journal taken out and reground until it was again perfectly true, straight and cylindrical. A second bearing was then put through its preliminary preparation and its final test run under the same conditions as the first had been, as nearly as care and skill could reproduce them.

Each mixture, as it was physically tested, was also chemically analyzed so that the effect of the various ingredients could be noted and recorded. Its price was also taken into account, so that a comparison of worth per dollar of cost could be made. In every case several duplicate tests were run in order that checks on each of the earlier tests could be had, with each mixture and in every case, and the average of several tests is used in compiling the accompanying data:

Four mixtures containing high percentages of lead were used, and three containing high tin percentages. Table 1 gives the chemical analysis of all the mixtures used. The capitals *L* and *T* indicate the major portion of each alloy, as being either lead or tin.

Details of Tests

The chart, Fig. 3, of the final test performance is plotted with time as abscissas and differences between room and bearing temperatures as ordinates. The first section represents the record under 200 pounds load, the second that of 300 pounds load, etc.; the point where the load was changed being indicated by a short vertical line. The sudden vertical break in the last section indicates the point where lubrication failed and the oil grooves smeared over, resulting in the complete and rapid destruction of the piece under test. To avoid confusion and undue crowding only the four most representative records are plotted.

Table 2 summarizes the increases in temperature for each load, the duration of run under each load and gives an approximate price per pound of each mixture.

The behavior of these bearings under the preliminary tests as well as in the final tests was very interesting. For instance, the high-lead mixtures, which, of course, would not stand peening into the shell, gave considerable trouble at first in obtaining a good support or backing for the bearing metal to the shell. This was because of their high shrinkage coefficient. The high tin alloys which do not shrink so much, in case of the anchors not being sufficient, could be peened solidly into the shell, and so eliminate troubles of this sort.

The high-lead bearings being the softer, were brought to a good running fit easier, but they would not recover when neglected or abused, with anywhere near the facility of the high tin mixtures.

The Mixture to Choose

Those mixtures showing a high content of antimony, as *L*3, were naturally hard and took a considerable length of time to come to their running fit. They were, therefore, somewhat less desirable than the softer materials, since any of the mixtures, well lubricated, will wear well enough for ordinary machine work, and the important quality of a babbitt mixture is its ability to adapt itself quickly to a deformed or roughened journal without undue heating or cutting.

The tenacity of the tin and copper in mixture T_1, combined with the ductility, render it easily the best of the group, but the high-lead mixture *L*4 seems the best of the combinations here listed, for ordinary work.

The high cost of mixture T_1 puts it entirely out of the question, except where special service requiring high quality to stand rough hard usage is demanded, or where the type of service makes uninterrupted running so important as to overshadow the item of first cost. In all other cases, of ordinary service, the tests show such an alloy as *L*4 to be very satisfactory, especially where, under reasonable conditions, a bearing may be expected to have good ordinary care, and a steady load in one direction, without violent and sudden reversals of pressures.

Even under such conditions, some practical master mechanics of long and varied experience in heavy rolling-mill work, have assured me that they would just as soon have a mixture like *L*4 placed in the bearings of a number of 3000-kilowatt gas-engine units, then under discussion, as to use the mixture sim-

TABLE 2. AVERAGE TESTS OF ALL THE DIFFERENT MIXTURES.

Name.	Cost per lb. in Cents.	200 lb.		300 lb.		400 lb.		500 lb.		600 lb.		700 lb.		800 lb.		900 lb.		1000 lb.		1100 lb.		1200 lb.		1300 lb.		1400 lb.		1500 lb.	
		Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.	Time Min.	Temp. Rise.
L_1	9.7	105	° F. 81	135	° F. 11	115	° F. 37	180	° F. 73	30	° F. 62	Fail	ed at 600 lb.																
L_2	7.4	100	79	75	5	155	9	160	130	Failed at 500		lb. Total Temp.																	
L_3	7.6	90	64	105	12	95	8	120	14	40	152	Failed at 600 lb. Total Temp. Rise 250°																	
L_4	7.3	115	69	70	8	85	3	115	11	55	145	Failed at 600 lb. Total Temp. Rise 236°																	
T_1	32.5	100	67	55	3	50	0	50	0	75	0	60	2	60	0	70	2												
T_2	24.7	145	109	235	102	Failed at 300		lb. Total		Temp. Rise 211°		50	5	50	1	45	3	25	90	Failed at 1000 lb. Total Temp. Rise 237°									
T_3	32	170	106	90	12	105	10	70	3	80	6																		

*Failed at 1400 lb. Total Temp. Rise 231°.

ilar to *T2*, which was furnished. They also assured me they had cured obstinate cases of hot bearings, where several varieties of tin mixtures had failed, by replacing them with a high-lead mixture. This ran very cooly from its first start and thereafter gave no further trouble.

SUMMARY

It is not my purpose to enter into any long or intricate discussion of the problems of bearing design, but in these days when forced and ample, even excessive, lubrication is daily becoming more popular, it would seem as if the conditions such as were used in the test could be closely approximated in most cases and thus the cheaper bearing be safely introduced.

If the experience of master mechanics of some of the largest steel plants is such as to find the high-lead bearing acceptable for the rough usage of heavy rolling-mill and the heaviest gas-engine practice known, it would seem at least worthy of a fair trial.

It is my own experience that a mixture similar to *T2* has stood the test for years of generator service at from 60 to 90 pounds dead-load unit pressures, with the possibility of a magnetic pull, due to an unbalanced air gap, doubling that pressure. It is also used with success in engine main bearings where the pressures withstood vary from 200 to 250 pounds per square inch and in crank-pin boxes where the momentary pressures at the point of admission of steam to the cylinder reach a maximum of 1400 pounds per square inch.

If a mixture of so poor a test record as recorded above, has so good a record in years of actual service under widely varying conditions, should not a mixture of a highly superior test record, with an initial cost of less than one-third of that of its rival, be given at least a fair opportunity to make a record by which it must stand or fall? It would seem so, and I will venture to predict that such will quite generally be the case in the near future and that under the policy of ample lubrication now gaining ground daily in power-plant service, the results will amply justify the experiment.

Compression in Steam Engines

By Armand Duchesne

The principal loss in the reciprocating steam engine is that due to the exchange of heat between the metal and the steam. In the ordinary case over 20 per cent. of the steam admitted is condensed to warm up the containing surfaces, and a large part of it is not re-evaporated until after the exhaust valve opens. Georges Duchesne did some original and notable work at Liege in measuring the variation of temperature of the cylinder surface and the author, his brother, tells of his own continuation of that work.

It has been demonstrated by the laboratory of applied mechanics of the University of Liège that the law of compression of steam in the engine is not the same as that of expansion, and it is not necessary, it appears to us, to search further for the loss of economy, due to the compression of the steam in the clearance spaces, discovered experimentally by Professor Dwelshauvers-Dery.*

There has been a collection of facts which have been brought to light at the laboratory of Liège, where I have the honor to labor under the orders of the learned professor, and in collaboration with my lamented brother, Georges Duchesne, which do not permit of any doubt upon this subject.

The genius of Hirn had led him to foresee a thing which we find at present very simple and very natural. He imagined that the temperature of the metal of the cylinder varied between limits much more narrow than those of the temperature of the working vapor, and the conclusion which he immediately deduced was that the vapor was dry at the end of the exhaust, since the hot metal had had the time to reëvaporate the film of water which had been deposited upon it. This probably appeared too simple and was not generally admitted, when Georges Duchesne gave a striking demonstration of the fact that it could not be otherwise, in such a way that only those who wished to remain ignorant of these proofs of the laws of physics who did not acquiesce in them.

Georges Duchesne had already determined the temperature of the metal during the exhaust of the steam,† and the comprehension of the phenomena depended only upon a knowledge of the properties of the saturated vapor of water. What would happen to several drops of water at the temperature of 110 degrees if they were placed suddenly under the receiver of an air pump where there existed a vacuum of one-tenth of an atmosphere? This is just what happens in the case of an engine operating condensing.

The hypothesis of Hirn was, therefore, demonstrated. The steam is dry at the end of the exhaust, and Georges Duchesne proved that it was even a little superheated.

An experimental verification of this fact would be of great interest, and we have been occupied for several years in obtaining it. The problem which we set for ourselves was to trace the diagrams of the temperature of the steam and of the metal for the two strokes of the piston forming a complete revolution. Our method has been already discussed,‡ but it has been modified, and we will describe it such as it is at present.

We needed evidently a thermometer which had no heat capacity, in order that there might be no lag, and we chose a thermo-electrical pyrometer, furnished with a platinum-silver couple, of which the elements had a diameter of 0.02 of a millimeter. This thermometer had a large number of junctures, which gave us consequently the mean temperature of all the steam in the cylinder. As to the walls, we used a pyrometer, made of two plates, one of silver and the other of platinum, of 0.002 millimeter thickness, applied to the walls of the clearance space in such a way that the juncture remained entirely free. In this way we are in command of two systems, one taking immediately the temperature of the steam, and the other the temperature of the walls. How could we register at each instant the temperature of the steam and the temperature of the metal?

By delivering the current of the pyrometer into a ballistic galvanometer during a determined time, one-tenth of a second for example, we have a deviation which, according to an established calibration, will furnish us the average temperature during this one-tenth of a second. This condition is realized by the fall of a weight, suspended by an electromagnet, the hight of that fall being calculated to continue for the required time. This corresponds with a speed of 30 revolutions per minute to one-twentieth of a revolution of the engine. It is necessary, there-

Revue de Mecanique, 1897, pp. 925 and 1236. POWER, June 28, 1910.

†*Revue de Mecanique*, July, 1899.

‡*Revue de Mecanique*, July, 1906.

fore, only to bring about the fall of this weight at the commencement of each one-twentieth of a revolution to arrive at the average temperature during the successive twentieth.

In order to realize this we have divided the two strokes of the piston into subdivisions, which correspond to the twentieth of a revolution (Fig. 1), and an electric contact could be broken by the crosshead itself at each of the subdivisions, in such a manner that the weight during the entire time of its fall will send the current furnished by the pyrometer into the galvanometer during the twentieth of a revolution, corresponding to that division and giving, therefore, the average temperature during this twentieth. It will be seen, therefore, that we could obtain points on the curves of the temperature of the steam and of the metal for an entire revolution of the crank, and it was necessary only to make these diagrams correspond to the corresponding two strokes of the piston in taking account of the obliquity of the connecting rod.

It goes without saying that if the speed is other than 30 revolutions per minute, one can calculate what must be the hight of the fall of the weight, in

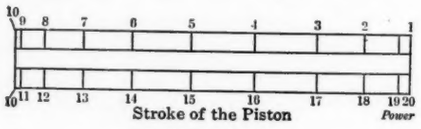


FIG. 1.

order that it shall continue through one-twentieth of the revolution of the engine. If the speed is only 15 revolutions per minute, the hight of fall of the weight should be calculated for a value of two-tenths of a second in order that it should correspond to one-twentieth of a revolution. Before undertaking specially the study of compression, we will describe an example of a test made without steam jackets, and which was made under the following conditions:

Expansion, commencement, 0.1; end, 0.95.

Compression, commencement, 0.9; end, 1.

It will be seen that the admission continued for one-tenth of a stroke of the piston, and that the compression was also one-tenth of the stroke.

The diagrams of the temperature are traced in Fig. 2, and we have added to these experimental curves those representing at each instant the temperature of saturation corresponding with the pressure shown by the indicator and the tables of saturated steam. It is seen at once that, excepting during the admission, the metal is always considerably warmer than the working fluid. The points of temperature of saturation are marked by small circles, and the diagram which unites them is traced in a dotted line. It is easy to prove that the steam is superheated well before the end of the exhaust stroke, with the result that at the commencement of the compression the degree of superheat attains 45 degrees.

During the expansion the two curves of the temperature of the steam experimentally determined and that of saturation taken from the tables correspond absolutely, and this suffices already to show us clearly that the fluid which is compressed is very different from that which operates during expansion. But we will show in that which follows the

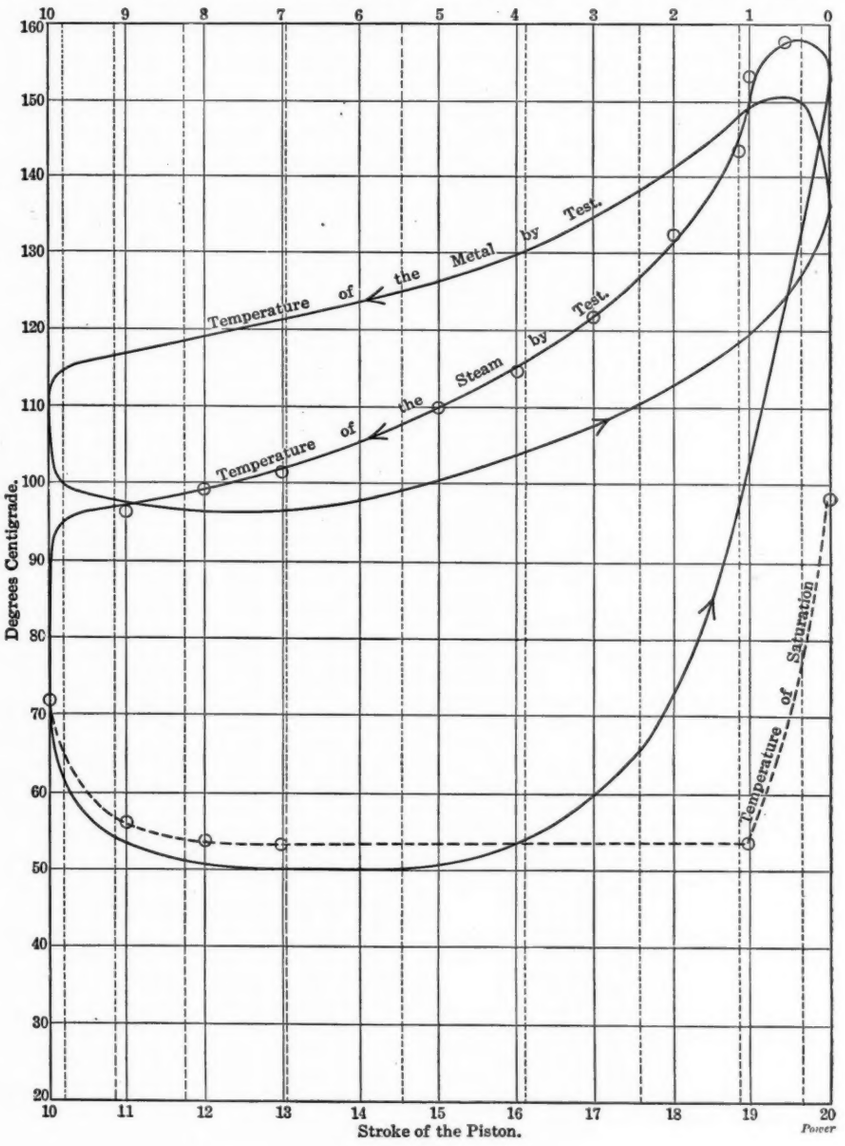

10 9 8 7 6 5 4 3 2 1 0
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20
Degrees Centigrade.
Temperature of the Metal by Test.
Temperature of the Steam by Test.
Temperature of Saturation
10 11 12 13 14 15 16 17 18 19 20
Stroke of the Piston.
Power

FIG. 2.

loss which is occasioned by compressing the vapor in the clearance space, when one exceeds a certain degree of compression.

To this end we have arranged our engine to realize a high degree of compression—nine-tenths of the stroke. In order, however, to more nearly comply with ordinary conditions, this long compression diminishing the time of exhaust, we have so adjusted the engine that the cylinder would remain in communication with the condenser during the same time as if we had a compression of only three-tenths. This was necessary in order to be able to draw the conclusions which we were after, the assumption being made that during this long compression we should have thus about the same weight of steam M_c, as if the compression had been shorter.

In Figs. 3 and 4 is given only that which concerns the compression. First, in Fig. 3, the experimental temperatures of the steam and the cylinder wall, as a function of the path followed by the crank pin, and in Fig. 4 these temperatures refer to the path of the piston. There is given also in a dotted line the curve of the temperatures of saturation.

And now there exists no doubt that a perfect gas is being compressed, the temperature of the steam going up to 450 degrees, while the maximum temperature of saturation is above 140 degrees, and this demonstrates that the theorem of Zeuner cannot be applied to the case

of the steam engines. We can, therefore, conclude at once that under the conditions in which we compress this steam it will require exterior work, considerably greater than that which it can produce, especially during the expansion, since at that time it operates under the form of saturated steam.

Let us try now to examine the loss of efficiency due to the compression in the case under consideration. We will suppose that the operation is adiabatic.** Let us take as the average specific heat of the superheated steam the figure 0.485, which we will suppose constant to the limit; that is to say, to the point of saturation. Leaving to one side the end of the curves, which show a sudden fall in the temperature of the steam and which will be explained later, we notice at *A A'* that the compression has raised the temperature from 86.5 degrees to 450 degrees. Upon the assumptions which we have made this operation has required an external work equal to

$$425 \times 0.485\ (450 - 86.5)\ Mc\ Kgm$$

**In view of the fact that the steam is superheated, we will not depart widely from the truth in making this assumption.

This would be nothing if the equivalent heat of this work could be retained in the fluid to be utilized in the following cycle. But what happens in reality beyond the point *A A'* is that the temperature of the fluid falls suddenly, the metal commences to cool the steam because the difference of temperature is enormous and the piston is moving very slowly; and if, under these conditions, certain portions of the metal remain cooler than the temperature of saturation, the cooling will produce condensation, and condensation means an exchange of heat extremely intense. It will be seen, therefore, that the heat which comes from the exterior work enters into the metal and will not be reimparted to the steam except in part during the expansion, but under unfavorable conditions of efficiency, since the temperature will be considerably lower than that at which the walls absorb the heat, and another part during the exhaust stroke, which is absolutely lost upon the efficiency.

Our researches on the properties of the superheated vapor of water permit us to calculate M_c.

$$M_c = 0.00445\ kg$$

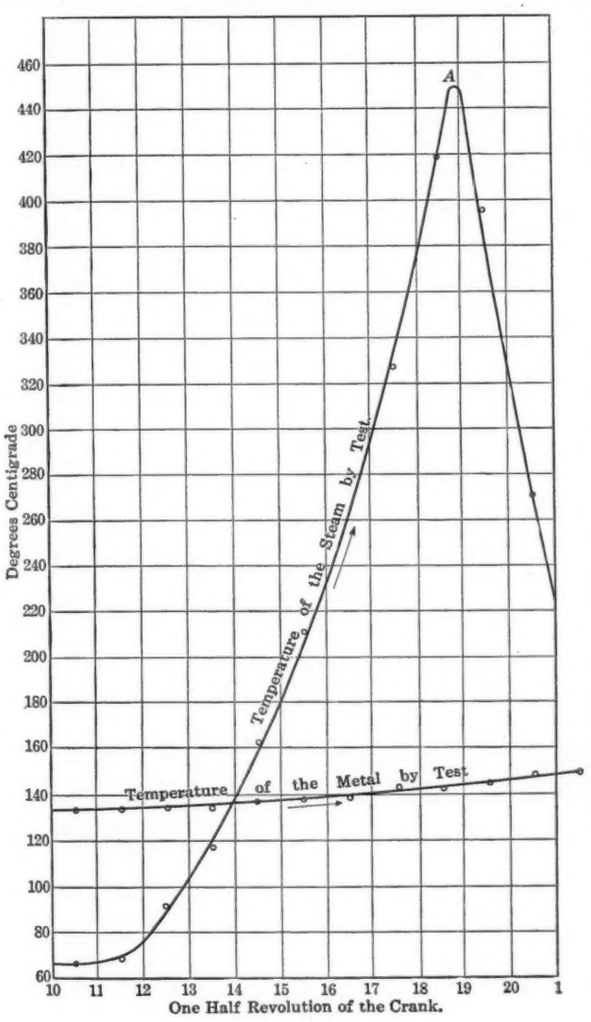


FIG. 3.

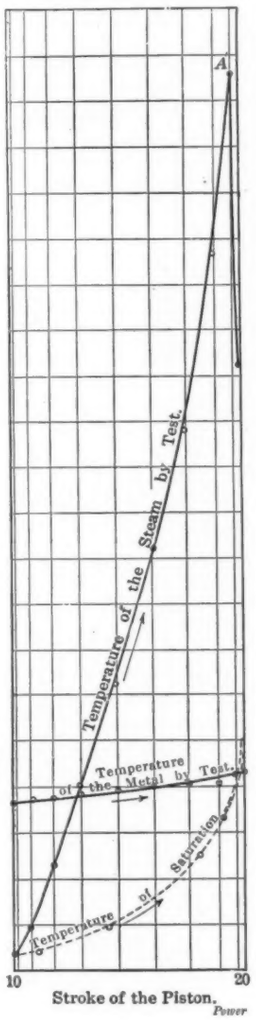


FIG. 4.

According to the preceding, we find that the compression has produced work of which the heat equivalent is

$$0.585\ (450 - 86.5) \times 0.00445 = 0.784\ calorie$$

of which the action of the walls will lose to us a great part of the benefit.

We have a verification of this figure. By measuring the area under the compression curves of the indicator diagram we should obtain the same results. By the aid of the planimeter we find that the mean hight of the curve of compression is 15.96 millimeters, the scale of the spring is 1 millimeter, or 468.1 kilogram per square meter. We have, therefore, during the compression a mean pressure of 7471 kilograms per square meter, the volume generated during compression being 0.04245 cubic meter. The work of compression measured up to the point *A A'* will be 317.1439 kilogrammeters, which corresponds to

$$\frac{317.1439}{425} = 0.746\ calorie$$

This figure is sufficiently near to that (0.784) found above to assure us of the exactitude of our measurements.

If we calculate the work per stroke by measuring the area of the indicator diagram, we will find 713.206 kilogrammeters, which correspond to 1.678 calories. We may, therefore, conclude that the loss of energy due to the compression by the mechanism which we have described is an important fraction, and that the 0.784 calorie, found as above, has a marked influence for this amount of heat; 0.784 is certainly not negligible as compared with the 1.678 calories, which represents the work developed upon one stroke of the piston.

But it may be said that we have chosen a compression of nine-tenths of a stroke, which would never be used in practice. Very true, but a long compression shows the influence much more markedly, and can we not deduce from it that we would reach the same results, but in a less marked degree, by a more feeble compression?

There still remains one point to be cleared up. For a given set of conditions Professor Dwelshauvers-Dery has found an increase of economy up to a certain degree of compression, and this is very simply explained if we consider a compression such that the temperature of saturation corresponding to the final pressure remains always less than the temperature of the metal. The effect will be that if at the end of the stroke the steam is somewhat cooled, it will not condense, but will remain superheated, and instead of producing a loss, will contribute to diminish the initial condensation.

It is in this way that the measurements of the temperatures of the steam and of the containing surfaces permit the phenomena which occur during compression to be interpreted.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Primer of Electricity

By Cecil P. Poole

The Compound-wound Dynamo

In the lesson of November 8 it was explained that the electromotive force at the brushes of a shunt-wound dynamo remains almost constant between no load and full load, but that the drop in the wires between the dynamo and the load makes it necessary to increase the voltage of the machine, when the load increases, in order to keep the voltage right at the load.

The series-wound dynamo, on the other hand, increases its voltage when the armature current increases, because the armature current passes through the field winding. This feature of the series-wound machine supplies just what the shunt-wound machine lacks for constant-potential work, but a simple series-wound dynamo cannot be used for this kind of work because its voltage varies too much with load changes.

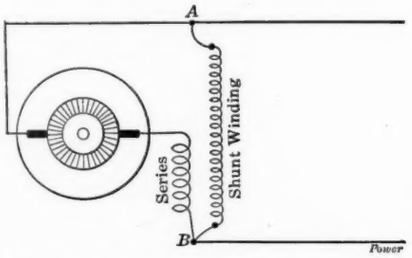


Fig. 82. Circuits of a Compound-wound Dynamo

Therefore, a field winding has been developed which is a combination of the shunt and series windings—in fact, there are two separate and distinct windings, one a shunt winding and the other a series winding, as indicated in Fig. 82, which is only an elementary diagram of the main circuits of a compound-wound dynamo, with regulating devices omitted. The shunt winding supplies the excitation necessary to generate the rated voltage and the series winding adds the excitation necessary to generate the extra electromotive force required to make up the drop in the dynamo and, if required, that in the wires of the external or load circuits.

For example, suppose the internal resistance of an 80-kilowatt dynamo were 1/35 of an ohm, the rated e.m.f. 230 volts and the full-load current 350 amperes. Then, at full load, the drop within the dynamo itself would be

$$350 \times \tfrac{1}{35} = 10$$

volts, and if it were not compound wound the voltage at the terminals would be only 220 volts at full load, unless the field excitation were strengthened.

In order to make the series winding strengthen the field excitation enough to make up the 10 volts lost in the windings, it would be proportioned so that with 350 amperes flowing through it, the ampere-turns would produce enough additional magnetic flux to enable the armature to generate 10 volts more than it would with the shunt winding alone. That is, the magnetism produced by the shunt winding would cause the armature to generate 230 volts and that produced by the two windings together would make it generate 240 volts.

In other words, if the machine required 8000 ampere-turns per pole to generate 230 volts and 8700 to generate 240 volts, the shunt winding would have to give 8000 and the series winding (at full load) 700 ampere-turns per pole.

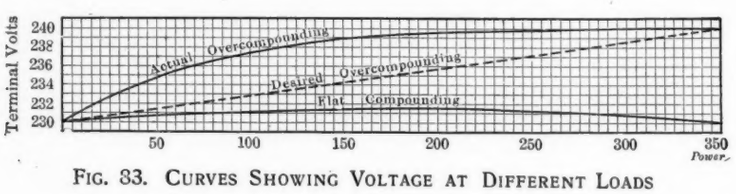


Fig. 83. Curves Showing Voltage at Different Loads

A machine built in the way described—to give the same voltage at full load as at no load—is called "flat compounded," because a curve showing the relation between the load and the voltage at the dynamo terminals is practically flat, as shown by the lower curve in Fig. 83.

Most compound-wound dynamos, however, are "overcompounded"; that is, when full-load current flows through the series winding the field strength is increased *more* than enough to enable the armature to generate the extra voltage required to make up for the drop in the windings of the machine itself. This is done to make up partly or completely for the drop in the circuit between the dynamo and the lamps.

For example, suppose the drop in the external circuit supplied by the 80-kilowatt dynamo were also 10 volts at full load and the machine had to be over-compounded to cover that drop. Then, at full load, the armature would have to generate 250 volts in all, 10 of which would be used up in the windings and 10 in the line, leaving 230 volts available at the lamps. If the machine required 10,000 ampere-turns per pole to generate this 250 volts, the series field winding would have to supply 1650 ampere-turns at full load because the shunt winding, which supplied 8000 ampere-turns when the e.m.f. at its terminals was 230 volts, would supply 8350 ampere-turns when subjected to 240 volts, which would be the terminal pressure when overcompounded 10 volts.

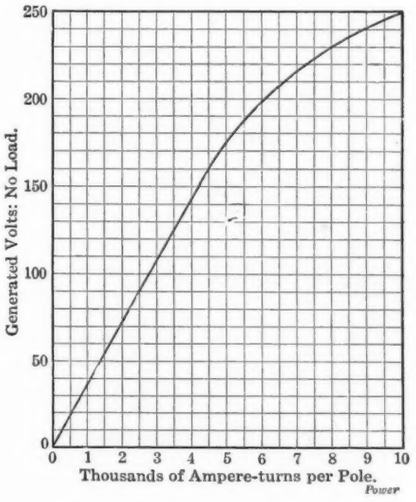


Fig. 84. Excitation Curve

As Fig. 83 clearly indicates, the compound winding does not do accurately what is intended, that is, maintain constant terminal voltage* with flat com-

*Terminal voltage is that at the terminals or circuit connections on the dynamo; *A* and *B*, in Fig. 82.

pounding or a rise in exact proportion to the load with overcompounding. In the case of the flat-compounded machine just described, the e.m.f. at the terminals, instead of being constant at all loads, goes up to 231½ volts when the load reaches 200 amperes, and gradually falls, as the load increases, to 230 at full load. In the case of 10 volts overcompounding the terminal volts increase rapidly with the load up to about half load and then increase slowly as the load increases, as shown by the upper curve in Fig. 83 marked "Actual overcompounding." What is desired is a regular increase in voltage, as indicated by the broken line.

The reason for this departure from constant voltage in the one case and a regular increase in the other is that the magnetism produced by the field excitation is not proportional to the excitation. This was explained in a previous lesson, and is illustrated by Fig. 84, which is the excitation curve of the 80-kilowatt machine now being considered. Referring to this curve it will be evident that the generated volts, which vary exactly with the field magnetism, increase exactly with the ampere-turns up to about 4500 ampere-turns; thus, 1000 ampere-turns produce 35.55 volts, 2000 produce 71.11 volts, 3000 produce 106⅔ volts, 4000 produce 142.22 volts and 4500 give 160 volts. Beyond this, the additional volts produced by each additional 1000 ampere-turns are less than 30 volts, instead of continuing at the rate of 35.55 volts per 1000 ampere-turns.

Fig. 85, which is the upper part of Fig. 84 plotted to a larger scale, shows more distinctly the relation between the ampere-turns and the generated volts of the 80-kilowatt machine, within the working range. This shows that 8000 ampere-turns of excitation enabled the armature to generate 230 volts; 8300 ampere-turns produced 235 volts; 8700 ampere-turns, 240 volts; 9000 ampere-turns, 243 volts; 9500 ampere-turns, 247 volts, and 10,000 ampere-turns produced 250 volts. If that part of the curve above 230 volts were a straight line instead of a curve, then the curves in Fig. 83 would be straight lines, so far as the machine followed them, but, as explained in a previous lesson, the machine would be unstable; that is, it would not stop at any particular voltage but would either increase to an infinite voltage and destroy itself or drop to no voltage at all and remain "dead."

For the reason just explained, it is impossible to get a straight-line excitation characteristic* from a dynamo. The curves shown in Fig. 83, however, are unusually bad and were selected because of that fact; they serve to illustrate the departure from a straight line better than curves taken from a well proportioned compound-wound dynamo would. The machine from which these curves were plotted was really a 240-volt shunt-wound dynamo.

*A curve or line on a chart showing the relation between different features of operation is called a "characteristic."

The field magnet of a compound-wound dynamo would be "worked" farther down the curve shown in Fig. 85, say along that part from 220 volts up to 240 instead of from 230 up to 250. The difference in

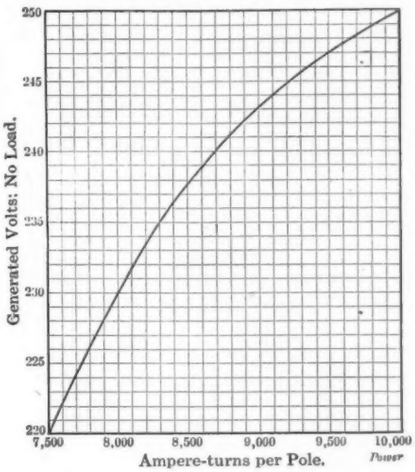


FIG. 85. UPPER PART OF FIG. 84.

regulation is quite remarkable. For example, if the full-load drop of the machine were 8 volts and it were compounded for a 12-volt rise at the terminals —that is, the terminal voltage at no load to be 220 volts and at full load 232 volts, the following results would be obtained:

	Ampere-turns.			Generated E.M.F.	Drop.	Terminal E.M.F.
	Shunt.	Series	Total.			
No load.....	7500	0	7500	220	0	220
Full load. ..	7909	791	8700	240	8	232

These results are deduced very easily. If the terminal voltage at full load is 232 volts and the internal drop is 8 volts, the total generated voltage at full load must be $232 + 8 = 240$ volts. Fig. 85 shows that 7500 ampere-turns are needed to generate 220 volts and 8700 to generate 240 volts. The shunt winding must contain 7500 ampere-turns when 220 volts are applied to it; therefore, it will contain 7909 ampere-turns at 232 volts. The series winding must contain at full load the difference between the 7909 supplied by the shunt winding and the 8700 required; this difference is 791 ampere-turns. Without going farther into details it is sufficient to say that the terminal voltage of the machine at one-fourth, one-half, three-quarters and full load would be as follows:

Load.	Generated Volts.	Drop.	Terminal Volts.	Desired Terminal Volts.
0.....	220	0	220	220
¼.....	228	2	226	223
½.....	233	4	229	226
¾.....	237	6	231	229
Full.....	240	8	232	232

Here, the greatest excess of terminal voltage over the desired voltage is 3 volts, as compared with 4½ volts excess in Fig. 83.

LETTERS

Water in Transformer Oil

"You had more transformers burn out in your little district during the last three months than we had in any of the larger districts in the same time."

The foregoing statement by the superintendent of construction to the superintendent of the little district mentioned caused me to do some thinking and investigating. I was the engineer of the plant and had nothing to do with the line work, but my natural curiosity prompted me to find out why so many transformers burned out. First I sought the lineman who had charge of the transformers and asked him in a casual way why so many transformers had burned out lately. As the burnouts occurred in transformers set up last and usually after a rain, he thought it was the wet weather that caused the trouble, but could not understand why, as the rain did not affect the transformers when hung on the poles.

Continuing the investigation I went into the building where the transformer oil was kept. The supply was contained in a steel barrel or drum which was placed on a bench high enough so that the oil could be drawn into a can set on the floor; from this can, which the lineman usually kept full or nearly so, he would pour the oil into the transformer cases because this took less time and he often had a hurry call for a transformer. I took this can out and poured out slowly the oil that was in it; then I saw that there was a considerable quantity of water in the bottom of the can. Following this clue, I discovered that the roof of the building where the oil was kept was leaky, and when it rained the can caught its share of the water, which was afterward poured into the transformer cases along with the oil. This impaired the insulation, ultimately producing short-circuits which burned out the transformers. The roof was repaired and the trouble ceased.

JAMES W. BLAKE.

New York City.

This is the season when the lecturer stands in the lantern's glare and descants upon everything from entropy to boiler-feed compounds for the benefit of the operating engineer. There is much to be gotten out of these lectures, and the opportunity to learn is not nullified by the fact that the lecturer may have as a motive the exploitation of his wares. One cannot know too much about the things he may be called upon to use, and discussion and a chance to hear the other man will bring out points about them that you never thought of.

Gas Power Department

Elementary Lectures on the Gas Producer

By Cecil P. Poole

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Fuel Bed Temperature

It is probably not clear to the student why the fuel bed in a gas generator does not become red hot all the way through, instead of being divided into "zones" as indicated roughly in Fig. 12. There are three reasons, each rather mixed up with the other; in the first place, the fuel bed is very deep—seldom less than three feet and usually from four to seven feet, according to the size of the generator; largely because of this, the principal reason exists, which is that not enough air goes through the fuel bed and into intimate contact with the particles of coal to burn it completely to carbon dioxide; the third reason is that the air is mixed with steam, as described in the first lecture last June, and this steam absorbs a lot of heat from the burning fuel in the combustion zone which would otherwise be transferred to the coal immediately above and raise the temperature of that zone.

This will be better understood, perhaps, if you will think over what happens when you pour water on a fire. If a little water be thrown on the fire it will be evaporated into steam and this will take heat away from the fire, dimming it considerably. If enough water be thrown on the fire all the heat will be absorbed and the fire will go out. The heat effect of putting steam through a bed of red-hot coal is the same, though the physical results are different. The steam is decomposed into hydrogen and oxygen and this process takes an amount of heat away from the burning coal equal to the heat that would be liberated by burning hydrogen to form the same amount of steam. This amounts to 62,000 heat units for each pound of hydrogen, or 6890 heat units for each pound of steam.

For example, each pound of carbon burned to CO_2 unites with $2\frac{2}{3}$ pounds of oxygen, which is taken from $11\frac{1}{2}$ pounds of air. The heat liberated by this combustion is 14,600 B.t.u. Now if, say, 9/10 of a pound of steam be admitted with the $11\frac{1}{2}$ pounds of air, that will be decomposed into 1/10 pound of hydrogen and 8/10 pound of oxygen and the decomposition will absorb 6200 heat units of the 14,600 set free by combustion; this will leave only 8400 B.t.u., instead of 14,600, available for raising the temperature.

The coal in the second zone has to be heated by the heat from the fire in the first zone, and if the temperature there (in the second zone) is kept at 1900 degrees, each pound of coal will absorb about 400 B.t.u. in "sensible heat" (see the December 6 lecture). Therefore, if there were $8\frac{1}{2}$ pounds of coal in the second zone for each pound of carbon burned in the fire zone, about 3400 B.t.u. would be absorbed in heating it up to 1900 degrees, so that instead of 8400 B.t.u. there would be only about 5000 available for heating the gases.

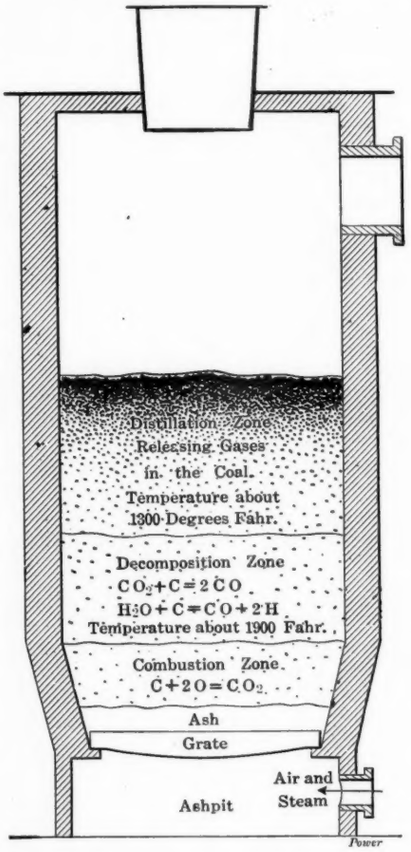


Fig. 12. Approximate Character of the Zones of a Fuel Bed When Steam Is Admitted with the Air

But in addition to the processes described there are two others which affect the generator temperature. The CO_2 formed in the fire zone "picks up" carbon in the second zone and is converted into CO; and the oxygen from the decomposed steam also combines with carbon to form CO. The first process absorbs heat and the second one gives out heat. For each pound of carbon united with CO_2 to form CO, there are absorbed 5700 B.t.u. and for each pound of carbon burned to CO with oxygen 4450 B.t.u. are given up.

Now, if we assume that all of the CO_2 formed in the fire zone is converted to CO in the second zone, that 9/10 pound of steam is admitted with the $11\frac{1}{2}$ pounds of air, that all of the oxygen from this steam unites with carbon to form CO, and that 3 pounds of coal are heated to 1900 degrees in the second zone for each pound of carbon burned in the first one, the burning of that pound would produce the following results:

1 pound carbon burned to $3\frac{2}{3}$ pounds CO_2 gives out	14,600	B.t.u.
3 pounds coal heated to 1900 degrees absorb	1,200	"
Leaving	13,400	"
$3\frac{2}{3}$ pounds CO_2 united with 1 pound carbon to form $4\frac{2}{3}$ pounds CO absorb	5,700	"
Leaving	7,700	B.t.u.
$\frac{9}{10}$ pound steam decomposed to $\frac{1}{10}$ pound H and $\frac{8}{10}$ pound O absorbs	6,200	"
Leaving	1,500	B.t.u.
$\frac{1}{10}$ pound carbon burned to 1.4 pounds CO with $\frac{8}{10}$ pound of oxygen gives out	2,670	"
Net heat remaining	4,170	B.t.u.

The final products of these processes are 6.067 pounds of CO, 8.84 pounds of nitrogen and 1/10 pound of hydrogen, and the specific heat of this mixture is 0.267 B.t.u. per pound or 4 B.t.u. for the whole 15 pounds. Therefore these gases will be at a temperature theoretically $\frac{4170}{4} = 1042\frac{1}{2}$ degrees above that of the atmosphere when they pass from the decomposition zone to the upper part of the fuel bed. The green coal there will absorb considerable heat from the gases so that when they finally leave the generator their temperature may be as low as 600 or 800 degrees, Fahrenheit. Of the 3 pounds of coal heated in the second zone, about $1\frac{3}{4}$ pounds have been used to make CO and the remaining $1\frac{1}{4}$ pounds pass to the fire zone to keep up combustion.

Many conditions other than those mentioned affect the temperature, such as the heat absorbed by the ash and that radiated through the generator walls. The calculations just given are intended only to indicate the way in which the fuel-bed thickness and steam supply affect the temperatures of the fuel and products of combustion and gasification. In practice it is impossible to convert all of the CO_2 into CO, and a considerable amount is always contained in the gases finally delivered by the generator.

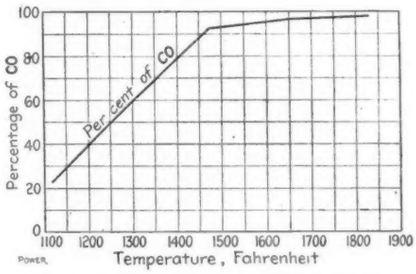


FIG. 14. EFFECT OF TEMPERATURE ON PRODUCTION OF CO

As the object of operating a producer is to make gases that will burn in an engine, and not to develop heat as a boiler furnace does, the less carbon dioxide it delivers, the better. Therefore, the aim is to completely burn just as little carbon as possible and to convert as much as possible of this back into CO, as described. It is necessary to make CO_2 in order to obtain the heat required to make CO; a fuel bed cannot be kept hot by burning all of the carbon incompletely, and it must be kept very hot to get the greatest proportion of CO in the outgoing gases. The conditions are contradictory to a certain extent. The quantity of CO_2 made in the fire zone must not be so great that much of it will go through the second zone unconverted; yet the second zone must be kept very hot in order to convert the greatest amount of CO_2, and in order to keep it hot a good deal of CO_2 must be made in the fire zone by complete combustion. The ideal fuel-bed depth and air supply are those that will burn just enough coal in the fire zone to heat the second zone up to that temperature at which the most CO_2 will be converted into CO. The deeper the fuel bed, the more coal must be burned in the fire zone to keep it hot and the more coal is burned to CO_2, the more steam can be admitted with the air without cooling the bed too much.

Boudouard, a French investigator, found that at 1112 degrees Fahrenheit, carbon dioxide passing through a bed of coal would combine with carbon to form 23 per cent. of CO, and at 1832 degrees the CO produced was slightly over 99 per cent. Fig. 14 was plotted from the results of Boudouard's tests. It shows that the percentage of carbon monoxide rose regularly with increasing temperatures up to 1475 degrees, beyond which point the increase was much less rapid. This chart indicates that the best temperature range for the second or decomposition zone is from 1800 to 2000 degrees.

As already explained, the temperature of the second zone depends on the depth of the fuel bed and the proportion of steam admitted with the air. Reducing the depth of bed will reduce the quantity of coal through which the CO_2 from the fire zone passes; the coal, therefore, will be heated to a higher temperature, and if the bed is too shallow it will increase in temperature until complete combustion occurs, unless the air supply is checked enough to prevent that. If that is done, the quantity of gas made will, of course, be reduced.

On the other hand, if the fuel bed is extremely deep the coal above the second zone may absorb so much heat from the rising gases that the temperature in the top part will fall low enough to allow some of the CO to be converted back to CO_2. This can happen either by the loss of the carbon "picked up" in the second zone or by the combination of CO with oxygen in steam which has been reformed or has escaped decomposition. In ordinary work this condition cannot arise because the generator is not high enough to contain any such depth of fuel.

It is asserted by some authorities that a slight conversion of CO to CO_2 occurs in the scrubber and gas passages due to the loss of carbon by cooling; this is said to account for the soot found in the scrubber water and the gas pipes, but the writer is more inclined to believe that that is merely coal dust swept from the upper parts of the fuel bed by the outgoing gases. However that may be, it is clear that the higher the temperature of a generator, up to that which gives the second zone 1900 degrees, the larger will be the percentage of useful gases and the smaller the percentage of CO_2 delivered. Any temperature above that merely wastes heat by increasing the temperature of the outgoing gases and also tends to fuse the ash in the coal and form clinkers.

A New Diesel Engine in Small Sizes

The "original Diesel small motors" shown at the International Motor Boat and Motor Exhibition in Berlin and at the Brussels World's Fair this year indicate that the development of the Diesel motor has been extended to the broad field of small high-speed motors.

This new type of Diesel motor, which is built at present in sizes of from 5 to 30 horsepower with one to six cylinders, is primarily intended to meet the needs of small industrial plants, and for this reason the aim of the builders has not been to obtain the greatest possible reduction of weight, but rather to provide a strong machine adapted to use by unskilled persons. Nevertheless, the new machines are lighter than is usual in stationary-engine practice. For instance, the weight of the 30-horsepower engine complete for service, including bedplate, air tanks, fuel holder and exhaust head, amounts to 32 kilograms per brake horsepower; this is about one-tenth of the weight of the old stationary Diesel engine of like efficiency, but greater than the weight of the submarine-boat engine, which, at any cost, must be lightly built. For installation in ordinary vessels the "original Diesel" small engine is provided with a modified crank case and the heavy foundation plate is omitted entirely, so that the weight of the engine for marine service is less than that of the land engine.

The speed of the small engine is normally 600 revolutions per minute, at which the combustion is incessant and the exhaust invisible and noiseless. The

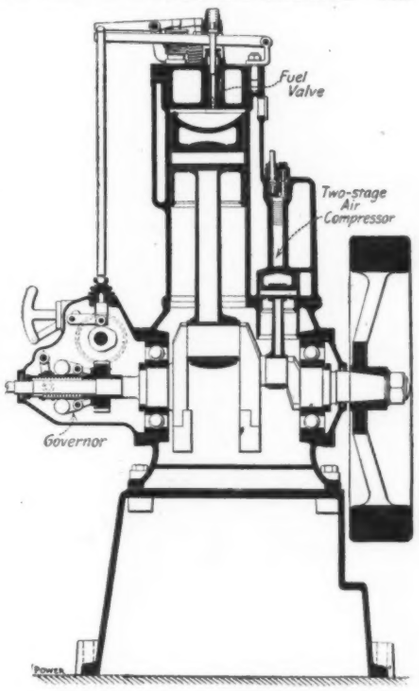


FIG. 1. SMALL DIESEL ENGINE

speed of the engines built for marine service, however, can be varied from 200 to 1000 revolutions per minute. The stationary engine is kept within 10 per cent. of the rated speed by means of the usual centrifugal governor. The problem of reliably controlling the injection of the very small quantities of fuel required is said to have been solved in the "original Diesel" small motor in a very satisfactory manner.

The machine shows several differences from the usual form of construction, some of them being characteristic features that have been developed in modern automobile practice. The cylinder head contains all valves and valve mechanism, and it extends into the cylinder

body, being packed by means of conical seat surfaces, metal to metal. Thus it has been possible to bring the larger piping, such as suction, exhaust and water pipes, to the cylinder instead of the cylinder head, and, consequently, the cylinder head is made very light and can be removed or replaced in a few minutes without dismounting clumsy piping or valve gearing. The arrangement of the valve-actuating levers on the cylinder head corresponds in general to that of the large types of Diesel motor; the cam shaft is, however, located directly above the crank shaft in an extension housing, as shown in Fig. 1, relieving the cylinder head still further of heavy parts. Fig. 2 shows a single-cylinder 5-horsepower Diesel small motor coupled to a direct-current dynamo.

For stationary service, in which constant speed is desired, the motor, as already stated, is provided with a governor, which is inclosed in the extension housing of the cam shaft and controls the length of stroke of the suction valve of the fuel pump. The marine engine is regulated by hand adjustment of the fuel pump.

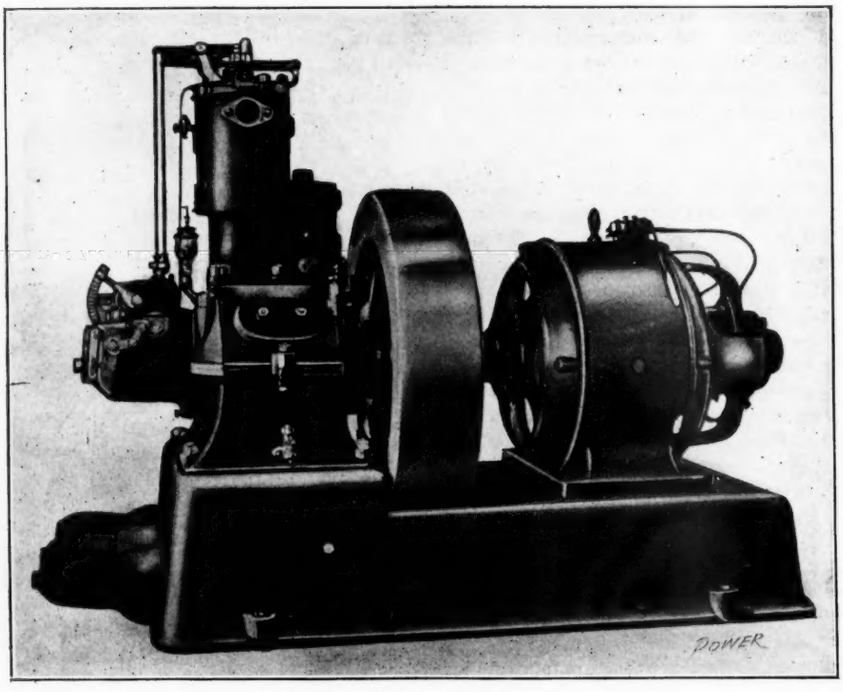


FIG. 2. SMALL HIGH-SPEED DIESEL ENGINE

Fuel-consumption tests at normal continuous loads have shown the exceedingly favorable result that the consumption differs only a little from that of the large engines. There have been obtained figures of 238 grams [8.4 ounces] consumption per brake horsepower-hour, so that 250 grams [8.8 ounces] may be taken as a guarantee figure.

According to data thus far obtained, the fuel costs for the Diesel small motors are only one-fifth to one-fourth of those obtained in gasolene-motor practice, and in marine service there is also the saving of fuel weight carried, which on the average is cut down to half of that required for the old motors. The radius of action of boats equipped with small Diesel motors, therefore, as affected by the fuel weight, is doubled.

As in the large engines, the fuels used are heavy oils of relatively "slow" inflammability; even with the most sluggishly inflammable oils, however, combustion is said to be so rapid that the indicator diagrams are indistinguishable from those of the large Diesel engine. The diagram shown in Fig. 3 was taken at reduced speed in order to avoid the distortions that would be caused by inertia of the indicator piston.

The inlet and oil-jet air is forced into steel tanks by the air pump, which, in its smallest type, is cast in one piece with the cylinder and is surrounded by the common water jacket. These steel tanks resemble the carbonic-acid flasks which for years have proved reliable. The ends of these tanks are shown projecting from the bed casting in Fig. 2.

The engine parts subjected to excessive stress, such as the crank shaft, crank pin, connecting rod and crosshead pin, are made of the best chrome-nickel steel; all bearings are ball bearings.

An improvement valuable in small service of all kinds is the automatic regulation of the air pump, which renders unnecessary any supervision of the air pressure in the various reservoirs. Since, also, the lubrication of the engine does not need special attention, this new small motor is a completely automatic machine.

These little machines are built by the Société Anonyme St. Georges, of Zurich, Switzerland. They are designated "original Diesel" small motors because they have been so named by Herr Diesel himself and their construction is carried out under his advice.

The Future of the Gas Engine

Dugald Clerk, the well known English authority, recently delivered a lecture at Manchester University on "The Phenomena of Explosions in Gas and Other Internal Combustion Engines." Mr. Clerk, in conclusion, expressed the opinion that so long as expansions remain as at present, no great further increase in the thermal efficiency of the internal-combustion engine can be expected. Increasing expansions mean increasing engine weight very largely to gain a small increase in efficiency. It is quite possible to design and construct an engine working with coal gas which would give an indicated thermal efficiency of about 50 per cent.; but such an engine would probably have a lower mechanical efficiency—probably about 80 per cent.—so that the brake efficiency would be only about 40 per cent. It is not likely, he said, that such an engine would be commercially successful, because the increased first cost would not be justified by the greater economy. Unless some other method can be adopted of increasing power by utilizing the exhaust heat, coal-gas engines are likely to remain at their present standard. The principle of compounding, it is true, might be applied to the gas engine, and longer ranges of expansion obtained; but such complication would be justified only in comparatively large engines.

So far as the small gas engine is concerned, a close approach has been made to a standard type. Practically all difficulties have been overcome, both from the engineering and the commercial standpoints. Small gas engines are now even more reliable than small steam engines, as may be proved by comparison of results given by various insurance companies. Scientific work is more vitally required in the case of the large gas engine, where the conditions as to temperature, pressure and unequal expansion due to heat are of the severest kind. Study of the various problems of volumetric heat, heat flow, radiation, incomplete combustion, dissociation, etc., are all required to produce better conditions of operation while maintaining or increasing thermal efficiency. Inventors of this generation may not succeed in producing sufficiently favorable conditions for commercial success in very large gas engines; but their work and that of the scientific investigator of the present will undoubtedly provide the engineer of the future with means of solving problems so far unsolved by the engineer of today.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Trouble with a Heating Plant

While putting in a steam-heating job of about 30,000 square feet of radiation, nearly all indirect, I ran across a problem that gave me some trouble to master, and the solution may interest some reader.

The building contained many wings and ells and as the several parts of it were built at different periods there are many changes of floor level; so that the steam main, all of which was run in the basement, had to rise, fall and rise again according to the various elevations of the basement ceiling. Altogether there are 1860 lineal feet of main steam pipe in the job, running from 10 inches at the boilers to 2½ inches in diameter at the extreme ends.

The boilers are located in the center of a court around which the building was built, and the main steam pipe ran in opposite directions from the boiler plant, feeding the north and south parts of the building.

The water line in the boilers was some 40 feet above the water line under the lowest radiators, so it was necessary to resort to the use of automatic feed pumps and receivers in order to return the water of condensation to the boilers.

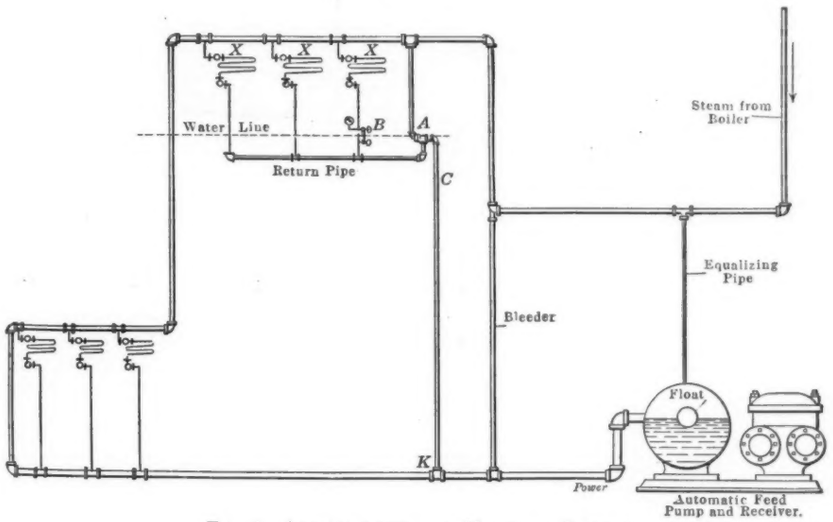


FIG. 1. ARRANGEMENT OF HEATING SYSTEM

Two of these pumps were installed, one of them being kept as a reserve unit.

Accompanying is a diagrammatic sketch, Fig. 1, showing the general arrangement of the part which gave trouble and how it was piped.

Soon after starting to heat the buildings it was found that the returns would come back to the automatic feed pump in slugs. The pump would run very fast for a few minutes, filling the boilers to the top of the glass gage before it slowed down, and then run very slowly for a while. The trouble was located at the point *A*, Fig. 1. A steam gage and a water glass gage were put on at *B*. The gage showed that for some reason, never clearly understood, the pressure in the pipe *C* was so much reduced at varying intervals that the pressure in the radiators *X X X*, which was constant, forced the water lying in the return risers and in the main return pipe over the trap seal at *A*.

This made an artificial water line in the highest of the several sections into which the system is divided, as before alluded to, notwithstanding the pressure from the equalizing pipe which was run from the steam main to the top of the trap in the usual manner.

All sorts of devices were tried to remedy this rush of condensed steam in the return pipe, but none of them did any good until the following plan was adopted:

There were on hand an old 2-inch steam governor and a 1½-inch flanged strainer which came from an abandoned reducing valve. With these to begin with, a device was made as shown in Fig. 2, in which the balanced valve of the old governor is set by the spring piece *F* at such a point as will allow the ordinary flow of condensation to pass. Whenever the reduction of pressure in pipe *A*,

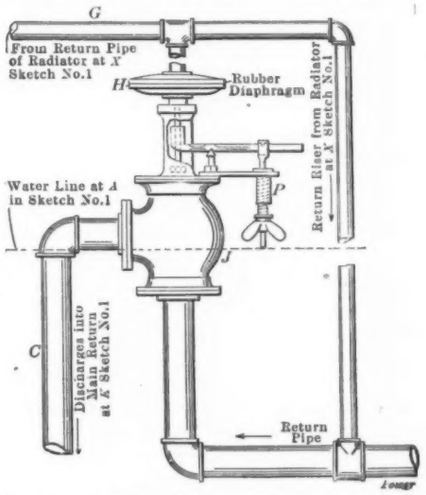


FIG. 2. DEVICE USED TO STOP RUSH OF CONDENSED STEAM

Fig. 2, occurs, the pressure from the steam main through the pipe *G*, acting on top of the diaphragm *H*, closes the valve *J* and the flow is checked, allowing only the regular flow of water to pass. When the pressure in the pipe *C* becomes normal, the valve assumes its original position and the regular flow of water continues.

There have been two of these valves in use for ten years and they have operated perfectly, the only attention required is the renewal of the rubber diaphragms once in about every third season.

I have never been able to understand just why the pressure was reduced periodically in the pipe *C;* and I would like to hear from engineers having experiences along this line.

T. H. DE SAUSSURE.

Milledgeville, Ga.

Simple Methods of Binding "Powers"

Each issue of POWER contains much valuable reading matter and information, which ought to be preserved for reference. I have just completed a satisfactory job of binding the issue for three months in one volume. This makes a

volume that can be easily handled, and a stronger and better job can be made than by making the volume of larger size.

To bind POWER proceed as follows: First arrange the various copies according to their dates, and pile in three sections containing one month each. Then remove the covers and lift the ends of the binding wires and take off the advertising pages, after which turn down the ends of the wires again.

Next take the first and second issue of the first month and glue them together; then glue on the third issue and so on until the whole of the first month's issues are securely glued together. Proceed with the second and third month's issues in the same way, taking care to make as neat a job as possible.

Next take the first month's issues, which form one part of the volume and glue it to the second part, and to this glue the third part, which will complete the volume in the rough.

Then take a piece of strong cloth and cut it a size equal to the depth of the book and wide enough to stretch across the back, and lap one-half inch over on the front page and the same on the last page. Cover the cloth well with glue and stretch it across the back of the volume as tight as possible, as it is the cloth that gives strength to the volume and keeps the parts firmly held together.

Take a clean cover of POWER and glue it in place, and the volume is finished. It is best to place the finished volume under a heavy weight for a few hours to allow the glue to set. The finished volume will look like an ordinary copy of POWER, only it will be about one inch thick.

GEORGE E. LAMBOWIN.

McKeesport, Penn.

Two Methods of Lacing Belts

Belts may be joined by lacing, riveting, sewing or cementing. A method of lacing a belt that may be relied upon is shown in Fig. 1.

First cut the ends of the belt square, using a sharp knife and try square. Then punch a row of holes exactly opposite each other in each end of the belt, using three holes for a 4-inch belt and five holes for a 5- and 6-inch belt. The number of holes in the row should always be uneven for the style of lacing shown.

A represents the outside of the belt and *B* the pulley side. The laces should be stretched as much as possible before using, and should be drawn half way through one of the middle holes, from the under side, as at *C*, and before proceeding see that the belt is not twisted, or, in the case of a crossed belt, that it has not been given a wrong twist. Then pass the end of the lace on the upper side of the belt through the hole *D*, under the belt and up through *E*, back again to *D* and *E*, through *F* and up through *G*. Then an incision is made in one side of the lacing which forms a barb that will prevent the end from pulling through. Then lace the other side of the belt in the same manner. This method may be used for belts up to 6 inches wide, but soft wire should be used instead of laces on belts smaller than 3 inches in width. If a lace is used on a small belt it makes

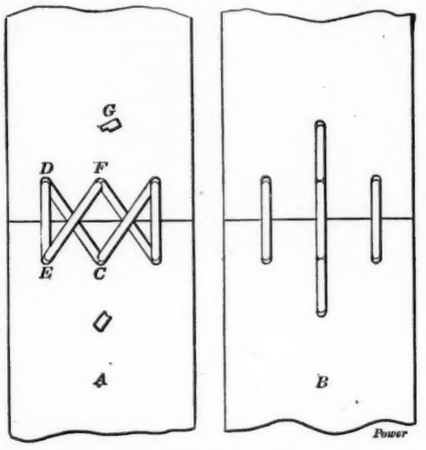


FIG. 1. A RELIABLE METHOD

the joint clumsy looking and the belt will travel unevenly over the pulley.

For belts wider than 6 inches the lacing shown in Fig. 2 is good. Two rows of holes should be punched. The number of holes in the row nearest the joint should exceed by one the number of holes in the second row. For 6-inch up to 7-inch belts I have always used four and three holes respectively. For larger belts make the total number of holes in

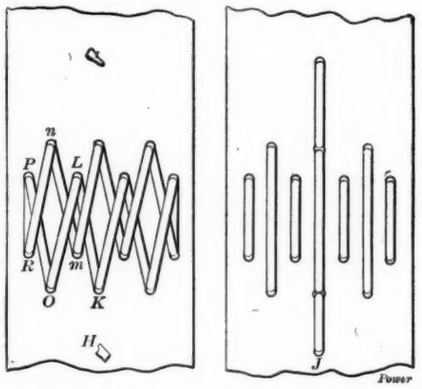


FIG. 2. LACING FOR LARGE BELTS

each end either one less, or one for each inch of belt width. I never care, with large belts, whether the number of holes near the end of the joint is odd or even. In a 10-inch belt, for example, nine and eight holes are used respectively. The outside holes of the first row should not be nearer the edge of the belt than ¾ inch, nor should the first row be nearer the joint than 1 inch. The second row should be at least 2 inches from the end of the belt. In Fig. 2, *H* is the outside and *J* the pulley side of the belt. Begin at one of the center holes, always in the outside row, as at *K*, and continue through *L, m, n, O, P, R, P, R, n, O, L, m*, etc.

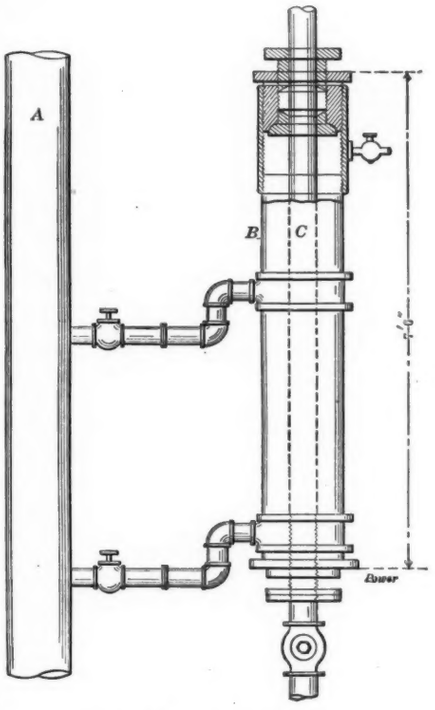
The lacing may also be started on one side instead of at the middle, and it should not be crossed on the pulley side of the belt.

WILLIAM L. KEIL.

Philadelphia, Penn.

Hot Water Reheater

Some time ago I had difficulty with the hot-water circulation in one of the buildings, due to the circulating pipe being placed about 6 feet below the lowest hot-water fixture, which is 12 feet below the main circulating pipe. This formed a trap and prevented the circulation of the water. There was also



HOT WATER REHEATER

danger that the line would freeze up in cold weather as the lower section was exposed to severe draft of cold air.

Therefore, I made a reheater on the riser pipe to the main, as shown in the accompanying sketch.

The steam is taken from a heating riser *A*, which is close by. The packing boxes of the pipe *B* are made of bushings which were filed out to fit the brass pipe *C*.

A swing check valve is placed below the reheater and at the lowest point on the brass pipe. This simple device reheats the water in the pipe *C* and establishes a satisfactory circulation.

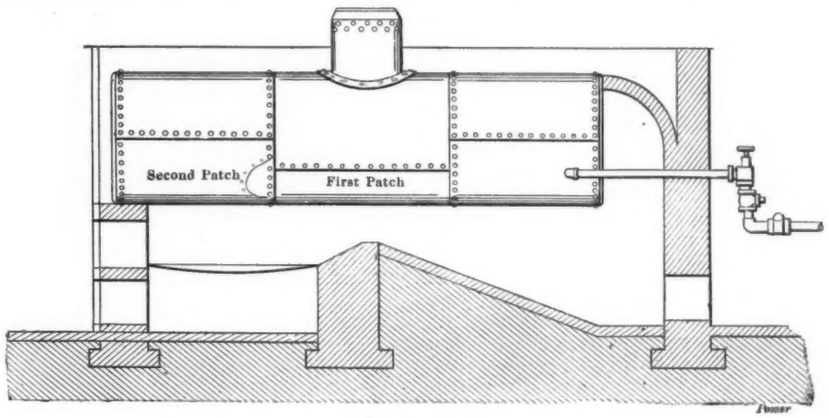
GEORGE PETERS.

New York City.

Patching a Second-hand Boiler

Some years ago the company I worked for traded their old boiler for a larger, second-hand boiler. After it was in place and all the pipe connections made, I filled it with water and built a fire, but before the boiler was warm, I noticed water dropping on the grates. Drawing the fire I found that the boiler was leaking at the first girth seam over the fire. This boiler was built, as shown in the illustration, and consisted of three sheets with single-riveted lap-joint seams. Securing a calking tool and hammer I tried to stop the leak, but was not successful.

After emptying the boiler I cut out a rivet and, holding a candle in the rivet hole, found that the under sheet was cracked in the rivet hole. Cutting out a rivet on each side of the first one, I found that the crack still extended beyond the remaining rivets. Considering this a job beyond me, I got a boilermaker to come and look over the boiler. He continued cutting out rivets until he got past the crack, which extended through twelve rivet holes.



PATCHED BOILER

We then cut out a piece of plate back to the next girth seam, as illustrated, and put in a patch.

After this job was complete, I filled the boiler again and got up steam, when I found that the tubes were leaking at the back end. By means of a tube expander and a trip into the back end about twice a week, I managed to keep things going for a while, but I soon reached the limit with the expander as the tubes were rolled so thin that it was impossible to stop the leaks by further expanding. I also discovered that the back head was in two pieces and that there was a seam about 2½ inches above the top row of tubes. When the water level dropped below this seam, I had trouble with the tubes leaking.

It became necessary in order to keep the plant running at all to consume a lot more fuel than should have been necessary. Then the boss agreed to get a new set of tubes and I cut out the old and put in the new ones. I found it necessary, in order not to roll the new tubes too much at the back end, to insert thin strips of copper around the tubes to help fill up the holes which had previously been enlarged. After this job had been completed, there was no trouble for about 6 months.

One morning, when starting a fire, I noticed a wet spot on the firebricks but not being able to discover anything wrong I fired up, but did not neglect to keep my eye on this part of the boiler.

During the day I noticed that there was a thin spray of steam and water coming from the seam near where I had noticed the wet bricks, and at once let the steam pressure drop. I found that the first sheet was cracked through nine rivet holes. A section was cut out and a patch put on as shown. This disgusted the owner so much with second-hand boilers that he purchased a new boiler.

WILLIAM G. WALTERS.

Stratford, Can.

The Way to Do It

Down at the big plant where they develop about 450 horsepower with 300 horsepower of boilers, with stationary grates and natural draft, they wheeled in one day a number of loads of screenings instead of the usual nut. The engineer in charge called the chief, and he in turn called Mr. Anti, the purchasing agent, who said that the screenings cost the company only the price of hauling and that they could burn them if they tried. He was taken at his word, but at about 4 o'clock in the afternoon every wheel stopped, and when the "big ones" gathered at the power plant they found the engineer and fireman trying to dig out what was left of those screenings. Mr. Anti seized upon the occasion to introduce some observations with regard to the advisability of an engineer learning to fire during his apprenticeship, and how the sawmill, of which he was president in the old country, never had as good coal as that. But here was where the worm turned, and the grimy engineer, wiping the sweat from his brow and handing the bar to the fireman said, "Do you know I have been figuring all the morning how to make steam with that stuff. How do you think it would work, Mr. Anti, if we were to lower the safety valve, close the quick return and feed it lightly on the crown sheet, with the crosshead wide open?" Whereupon Mr. Anti, whose dignity was sorely hurt at being led into a discussion with a common engineer, answered, "Why, any fool would have tried that at first. That's the way we used to burn it over in the old country."

A. GREENHORN.

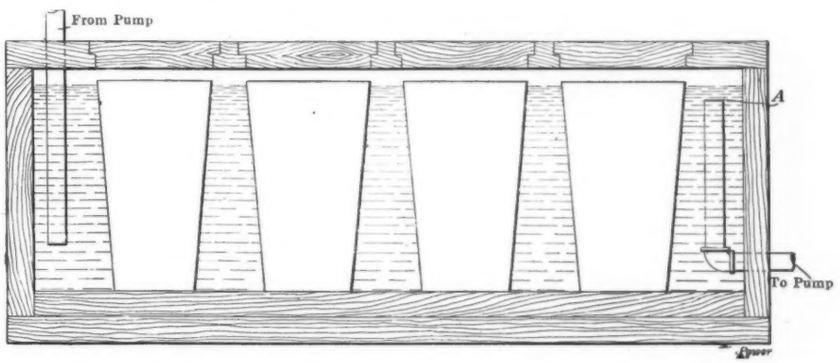
Edmonton, Alta., Can.

Brine Foamed

When pulling ice from our tank, trouble was had with the brine foaming. The foam was very thick and resembled soap suds, and when it overflowed into the cans the water was spoiled for ice making.

Upon investigation it was found that too many cans were pulled before any were filled and put back in the tank. This allowed the brine level to fall to the top of the pipe *A* and air was drawn in at the open end, and this air caused all of the trouble.

Now, the men pull fewer cans at a time and there has been no more trouble with foaming brine.



PIPING OF CAN TANK

MYRON D. PLACE.

Foxboro, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Steam Boiler Economy

I have noticed several articles in recent issues of POWER on the subject of flue-gas analysis and CO_2 recorders. The main object of these seems to be that of inducing engineers to write of their experiences with CO_2 recorders and of what success or failure they have had with such instruments.

In view of the fact that flue-gas analysis is almost essential to high furnace efficiency, and that the largest part of the expense of operating a plant is concentrated in the boiler room, very few engineers are making any progress in the study of saving fuel and building up furnace efficiency.

I have tried to learn from several engineers who do not use CO_2 recorders or flue-gas analyzers, just why they have never given this subject more consideration and have most of their reasons embodied in the following answers:

One engineer says that not having sufficient knowledge of the chemical composition of flue gases caused him to lose interest in the economical combustion of fuels. He took an interest in steam-engine indicators because his plant was equipped with them, and likewise was familiar with all other instruments at his disposal.

Another says that lack of training in chemistry prevents the average engineer from understanding chemical analysis and he does not like to believe anything beyond his knowledge.

Another states that apparently his furnaces are giving full efficiency and all the available heat is utilized and to purchase the necessary apparatus would be a waste of money.

Still another says that the required information on the fundamental principles of flue-gas analysis has not been obtainable in the columns of POWER or in textbooks so that the average engineer could educate himself to the point where he would be adequately qualified to handle this work. The results of several tests have been published but nothing which would aid the man unfamiliar with this work to take the necessary elementary steps toward possessing himself with the ability to economically burn the fuels and consequently reduce the coal bills by virtue of the proper use of instruments. Progress in this direction has not been as rapid as we would expect for a problem of so great importance. Good results are, however, being obtained from some of the later models and coal is being saved in appreciable quantities and if engineers would write their experiences or ask for information, thereby benefiting all interested, the chance would be lessened for readers of POWER to return answers similar to the above when approached on the subject of CO_2 recorders and the economical burning of coal in their boilers.

CHARLES M. ROGERS.

Detroit, Mich.

The editorial in the November 22 issue on CO_2 records should have the effect of awakening engineers to a sense of what their duty is in this age of advancement. The day is past when an engineer was judged by his ability to shovel coal and employers are beginning to realize that the engineer is one of the most important men in their establishment. The other branches of mechanics (with the improvements of machinery of this age) are gradually falling away and the mechanic of the past is now just a link of a great machine. With the engineer it is different, for with the improvement of machinery and with the substitution of machines for manual labor his duties are increased by the responsibility for and care and management of these machines which come under his direct charge.

It is, then, up to the engineer to meet his duties and to educate himself so that when the demand is made he will have the ability to fill the position which calls for the assumption of increased responsibilities.

The engineers of Ontario, Canada, are probably up against a harder proposition than the engineers situated in any other part of America. The transmission of electricity by the government throughout the province of Ontario brings electrical energy from Niagara into direct competition with the steam plants. It is up to the steam engineer to demonstrate his ability and compete with this new form of power. In many establishments where heat is required and where the exhaust steam can be utilized for heating purposes, if the engineer can put up any kind of a showing with the steam plant, Niagara power will never get a foothold. Many large companies, after going into the matter thoroughly and taking into consideration the fact that the climate makes it necessary to heat the buildings during about seven months of the year, have installed steam plants and are generating their own current and using the exhaust steam for heating purposes, and have demonstrated to their own satisfaction that, after taking into consideration the heating of their establishment, the ledger comes out right by a large margin in favor of the steam plant.

Now a word along the line of the editorial. It is true that the great savings in the future are to be made in the boiler room. But, as the average engineer is not very proficient as a chemist, it will require considerable agitation to get him started along that line. I have been thinking of the subject for some time and on reading the editorial I commenced to look through the advertisements, but I am unable to see what I wanted there. POWER would certainly be conferring a favor on the engineers who are interested along this line, and would draw into interest those who are not, if it would enlarge on this subject and give us a lesson along this line every week, and also intimate to the manufacturers of recording instruments that a little printer's ink used judiciously would have a tendency to increase their business. If the engineers can be awakened to take an interest in this subject and also along the line of keeping complete records in every line in the steam plant, it will certainly increase their interest in the profession, and will benefit them financially and cut down the operating expenses to such a degree that we need not be afraid to enter into competition with any new development that may enter the field of industrial progress.

W. G. WALTERS.

Stratford, Ont.

Boiler Room Emergencies

One of the most common and least dangerous emergencies in boiler-room practice is the breaking of gage glasses. With the steam rapidly escaping into the boiler room, it is only necessary that the inexperienced fireman keep his wits about him. The lower gage valve should be closed first, thus stopping the flow

of water, after which it is an easy matter to close the upper valve, from which steam only is emerging. Until time can be found to renew the glass, the water level can be determined by means of the try cocks. The upper cock should show dry steam, the lower water, and the middle one steam and water. Spare glasses should be, and usually are, kept on hand for such emergencies.

Another emergency to be met is that of finding the water either too high or too low. The boiler is in no danger from high water, but a wrecked engine is liable to be the penalty for such carelessness. The remedy for high water is to blow down the boiler. This, however, is not necessary if the engine has shown no signs of getting water, and it is known that no sudden load will be thrown on. Under such a condition it is only necessary to stop the feed pump until the water is down to normal.

To suddenly discover that the glass contains no water is an emergency which calls for quick action on the part of the attendant. If it is definitely known that the glass contained water only a very short time before, and that no sudden demand for steam has been made on the boiler, which could possibly have lowered the water sufficiently to expose any of the heating surface, and that the boiler has sprung no leaks, the attendant may feel reasonably safe in opening up the feed supply and raising the water level to normal. However, if there is any doubt as to whether or not the water has reached a dangerously low level, no time should be lost. The fire should be deadened, using ashes or green coal. The damper and ashpit doors should also be closed, and the furnace doors opened. If the boiler is in a battery, the pressure on all should be lowered as much as possible without interrupting the service, after which the boiler should be cut out, cooled off and inspected for burned plates. If no signs of overheating are found, it may be fired up and placed in service.

Another emergency which calls for very quick action is the sudden discovery that the steam pressure is considerably higher than it should be. This is not liable to occur in a well kept plant, or when the boilers are in a battery, where each is protected by its own safety valve. The present practice of equipping boilers with two safety valves further limits the probability of excessive pressure.

When, from any cause, the pressure in a boiler is found to be abnormally high, the first thing to be done is to deaden the fire, thus preventing a greater rise in pressure. The practice of drawing the fires is not to be recommended as it is sure to increase the furnace temperature. The better method is to smother the fires, as for low water. No valve connected with the boiler should be touched; this especially applies to the safety valve, before the boiler pressure has dropped to normal.

Perhaps the most severe emergency to be met in the generation of steam is the rupturing of any part of the boiler. Under this condition the attendant must be governed entirely by the circumstances and surroundings. Stopping the generation of heat and increasing the water flow are the two things most essential to be done, until the pressure is sufficiently lowered and the boiler cooled.

J. M. Row.

Fort Flagler, Wash.

Trouble with Water Column

I read with a good deal of interest the short article on "Trouble with Water Column" in the November 29 number. I lately had a similar experience to that described therein. I came to the conclusion, however, that the trouble was caused by the condensation of steam in the upper part of the column which caused the pressure to fall at that point and hence the pressure in the boiler, acting on the water in the column at the bottom forced it to the top of the glass.

To anyone who has experienced trouble of the kind I would recommend the following remedy: Make a box of either sheet iron or light wood and fasten or hang it in some way to the boiler front and thus inclose the whole column leaving only the glass exposed. Then, fill the box with, say, charcoal dust. Leave the glass in connection with the boiler both at the upper and lower end during the time when the boiler is banked. When steam is again raised, the trouble will be gone.

JOHN ZETTERLUND.

Eskilstuna, Sweden.

The "Trouble with Water Column," described in the article under that head in the November 29 issue, was undoubtedly caused by the filling up of the lower connection with mud or sediment. In many boilers trouble is caused in this way, to a greater or less extent. Last year the water columns on my boilers began to get a little slow. They were piped with 1¼-inch top and bottom connections, with a ⅜-inch blowoff connection under the 1¼-inch cross valve. The cause of the trouble lay in the small size of the blowoff line, which would not let the water move fast enough to dislodge the mud in the lower connection when blowing off the column. I removed the ⅜-inch line, and substituted 1¼-inch pipe in its place, and connected it to the main blowoff line. With this arrangement, when I blow off the column, the water passes through the lower connection with force enough to carry off any and all sediment that has found lodgment in the column.

E. H. ROBERTS.

Norwalk, Conn.

Exhaust Steam Regenerators

In the issue of November 8 there is an article by Charles H. Smoot under the above title. In one instance, the article seems to contain an inaccuracy. In the last column on page 1983 the statement is made that the efficiency of a well designed injector for boiler-feed purposes does not exceed 20 per cent.

When an injector is used only to lift water and the heat put into the water by the steam passing through the injector is wasted, it may be true that the efficiency cannot exceed 20 per cent. But, when an injector handles boiler feed, all of the heat imparted to the water goes back into the boiler. In such cases the efficiency is very high, possibly 98 or 99 per cent. It seems to me that the set of similar conditions surrounding the use of the injector principle in a regenerator would permit a high efficiency to be obtained.

KARL LEFREN.

Lowell, Mass.

Water Gage Connections

With regard to Mr. McGahey's letter in the December 13 number, I believe that I am right when I say that fully 90 per cent. of the engineers favor valves placed in the water-column connections. It has been said that a careless boiler attendant might close one of the valves for some reason and forget to open it again. Just so—a careless boiler attendant might do any of a hundred other possible things, but it is the duty of the head to see that no careless boiler attendant is allowed on the job.

JAMES E. NOBLE.

Toronto, Ont.

Experience of an Indicator Man

In the December 6 issue of POWER, W. E. Hopkins makes a few comments on how easy it would be to get an even cutoff on a corliss engine, by stating that, if the cutoff was equal, both steam valves would stop cutting off at once. Does he not know that if the dashpots both raised to the same hight before cutoff took place that the engine would have too late a cutoff at the head end? Mr. Hopkins certainly knows that the piston of any reciprocating engine travels faster in either direction in the head end of the cylinder than for any corresponding position in the crank end, after the crank pin is past the quarter turn on the crank-end side; and a thinking man can easily see that the steam valve on the crank end would have to remain open longer to get a steam line equal to the head-end steam line. The only way to secure this longer interval is to have the pot lift higher before cutoff takes place.

LEROY H. WHEAT.

Emmitsburg, Iowa.

Installing Globe Valves

For a number of weeks past there has been a discussion on in the columns of POWER as to the proper method of installing a globe or an angle valve.

For several reasons, the chief of which is that I believe it to be the only safe method, I am strongly in favor of having the pressure come under the disk, tending to open the valve and throwing the stress of the steam pressure on the threads of the stem, when the valve is closed.

About ten years ago I witnessed an incident which came near being an accident, and which convinced me of the danger of having the pressure come over the disk.

In the plant of which I am now in charge we had at that time six horizontal return-tubular boilers, all 66 inches in diameter. Nos. 1 and 2 were lap-joint iron boilers 15 feet long; the other four were lap-joint steel boilers 18 feet long. All of these boilers were fitted with 5-inch lever safety valves on the front nozzles, and 5-inch angle stop valves on risers from the rear nozzles. The stop valves were placed with the stems horizontal and the boiler pressure came above the disk, tending to hold it to its seat.

On No. 1 boiler the safety-valve lever was turned toward No. 2 boiler and reached nearly half way over the setting. There was a 1¼-inch steam pipe which came down between the front of boilers Nos. 1 and 2 and passed horizontally close to the end of the No. 1 safety-valve lever. This pipe was used for tube blowing and the steam blowers under the grates.

Now, we have great difficulty, out in the country here, in getting good men for night watching and boiler tending. Nobody wants the job at any price; we have almost to beg men to take the job. Importing men from the neighboring city is a dead failure; about three days is the average city man's stop on the job. Nothing doing, you know; and they come and tell you, "It's too lonesome here," and can they get their pay? So, generally, our night help on the boilers is pretty poor. At the particular time to which I am referring, our night men were particularly thick in the head.

One morning in January, 1900, the man on the fires in some way or other got the 1¼-inch blower pipe moved or sprung over the end of the No. 1 safety-valve lever, thus holding the valve tightly to its seat. The Nos. 1 and 2 boilers had been banked during the night and the stop valves closed. When the watchman had raised the pressure in these boilers to equal that in the line, he opened the stop valves, or supposed that he did, and as it was cold he started to build up some pretty big fires.

These two boilers were 20 years old and insured for 90 pounds pressure. They had had considerable repair work done on them at one time and another and were not considered to be very safe for pressures over 100 pounds. It was lucky indeed that the master mechanic, who had charge of the boilers at that time, got down earlier than usual that morning. When he got into the boiler house, the watchman told him that the No. 1 pressure gage was out of order; the pointer was loose, he thought. It was a 150-pound gage and when the master mechanic looked at it the pointer was where the 155-pound mark would have been if the scale had extended that high. He got a ladder to get at the gage, and then noticed that the pointer was vibrating stiffly and was evidently tight on the spindle. Just then his eye caught sight of the pipe over the safety-valve lever and he jumped up and tried the stop valve. From the feel of the valve he concluded that the disk was off the stem and that the boiler pressure was holding the valve closed. Then, he got excited and jumped for the safety valve, sat on the lever and sprung the steam pipe free and then got off and let her blow. She did; considerable. No, there was no water hammer, and the boiler did not go through the roof. It stayed right where it was and blew down to the regular pressure in a commonplace but noisy manner.

The fire was drawn, the pressure reduced and the valve bonnet removed. The disk had pulled off the stem, the stem collar pulling through the nut.

Now, if this valve had been put on the "other end to" with the boiler pressure under the disk, there would have been no dangerous trouble at all. It would not have been necessary to shut down the boiler to fix the valve at that time; it could have been left for a more convenient time. Of course, the stop valve was not responsible for the blocking of the safety valve; it was merely a coincidence that the safety valve was useless when badly needed. That steam pipe was moved before noon that day. All the stop valves on the other five boilers lost their disks in the same way a number of times after this, but as the safety valves worked, nothing exciting or dangerous happened.

As soon as I was given charge, I had all of these valves turned so as to bring the boiler pressure under the disks; and I never had any trouble with them. The No. 1 boiler was apparently not hurt by its experience of high pressure, for we ran it hard for four and a half years after the occurrence until the insurance company lowered the pressure to 50 pounds. Boilers Nos. 1 and 2 were replaced in November, 1904, with two 72-inch by 17-foot butt-joint steel boilers of the same make. The old boilers were 25 years old when replaced, and were cut up right away. We never sold an old boiler, as a boiler; it was always cut up for junk; if it was not safe for us, it certainly was not safe for anybody else.

Now, a globe or an angle valve with the pressure under the disk may fail in two ways. The threads on the stem or in the bonnet may strip, or the disk may split in two. In either case the valve would be open for the passage of steam and if the disk is whole and only the threads stripped, the valve may be closed by means of a lever over the top of the stem; the steam pressure will open it again when the lever is released.

When the pressure is over the disk, the valve may fail by stripping the stem or bonnet threads, by the stem pulling in two or by the disk coming off the stem, caused either by the stem collar pulling through the retaining nut or by the threads of this nut stripping or the nut backing out. In all of these cases of failure the valve would be closed to the passage of steam, and it would be impossible to open it under pressure except in the one case of the stem or bonnet threads stripping, in which case the valve may be opened by means of a lever under a collar or lathe dog on the valve stem. However, when the pressure comes over the disk, 75 per cent. of the failures are caused by the disk in some way coming loose from the stem.

In the December 13 number of POWER, J. W. Parker speaks of two throttle valves in which water hammer had upset the stems, and says that he advised reversing the valves. I do not think that this advice was good, for if the water hammer was severe enough to upset the valve stems when acting from under the disk it would quickly drive the disk off the stems if it acted on the top of the disks, and then the valve could not be opened at all and he would be in a worse fix than the upset stems put him.

The inspection department of the Factory Mutual Fire Insurance Company would quickly make him change the fire-pump throttle so as to bring the pressure under the disk. They will not accept a gate valve on a fire-pump steam line; it must be a globe or an angle valve with the boiler pressure under the disk.

As to feed valves, they should be placed so that the feed-pump pressure comes under the disk, and an extra valve should be placed between the check valve and the boiler so that the check valve can be reground or the feed valve repacked while steam is on the boiler.

Never place a valve on the feed line in such a way that if the disk comes loose the pump pressure will close the valve and obstruct the feed line.

Angle blow-down valves may be the one exception that goes to prove the general rule, but in all other cases I want the pressure to come under the disk of a globe or an angle valve. Blow-down valves are constructed so as to protect the seating surfaces of the valve body and disk, and the position the valve is placed in depends a great deal on the method used to protect the seats from the cutting action of boiler scale. I

heard of a case in one plant where they had lots of trouble getting the water out of a boiler, owing to the blow-down valve plug or disk coming off the stem.

BENJAMIN S. HANSON.

Broad Brook, Conn.

Liquid Discharging Device

Mr. Pagett's description of his invention for discharging liquids from barrels looks very much like a device that I made some years ago, to empty oil from barrels to the shop tank, only he has not given a very necessary dimension, that is, the size of the air inlet.

In making my device I figured on using 80 pounds air pressure, but as I did not think a barrel would stand that pressure I reduced the inlet for the air to 0.03 of an inch in diameter, figuring that the oil would run out of the 1-inch exhaust pipe fast enough to keep down the pressure, which it did, and the thing worked fine. I used it in the shop for several months, until one day the helper whose duty it was to look after the oil used it in a barrel of lard oil that was chilled. He put in the device and turned on the air and in just a minute the lard oil was all over the floor and the helper looked as though he was suffering from shock; I know that I was.

I have never seen my device from that day. It may have gone West. I would advise anyone who wants to use Mr. Pagett's invention to see that the inlet hole is something less than 0.03 of an inch in diameter for 80 pounds pressure and that there is a safety valve on the job.

J. J. SEIBERT.

Washington, D. C.

The Expansion Valve

In looking over the October 25 number of POWER, I came across an article by Mr. Reynolds in criticism of an article, in the August 30 number by Mr. Nash, regarding the expansion valve.

In reading the two articles one would conclude either that one of the gentlemen is not posted or that expansion valves differ greatly.

I will not attempt to tell anything about Mr. Nash's expansion valve nor yet about the one operated by Mr. Reynolds, but will tell you about one which I have in connection with an absorption machine which I am operating at present.

The best way of which I know to describe the action of ammonia in the brine cooler is to compare it to the well known action of water in a steam boiler, both under operating conditions. In fact, from a mere verbal description of a brine cooler and steam boiler it would be very difficult to distinguish one from the other.

By way of comparison, I will say that a steam boiler is a cylindrical shell with tubes or pipes extending from end to end and so is a brine cooler, though the pipes in the brine cooler are formed into coils.

The boiler is partly filled with liquid (water) and the remaining space is filled with gas (or steam).

The brine cooler is partly filled with liquid ammonia and the remaining space with ammonia gas. In the steam boiler part of the heat in the flue gases which traverse the tubes is absorbed by the water. a part of which passes into steam.

In the brine cooler part of the heat in the warm brine which traverses the tubes is absorbed by the liquid ammonia, a part of which passes into ammonia gas.

In the boiler the temperature of the flue gases is lowered and the water would soon cease to boil or give off steam if more heat was not supplied by replenishing the fire.

In the brine cooler the temperature of the brine is lowered and the ammonia would soon cease to boil or give off gas if more heat was not supplied in the form of more warm brine.

Water is a great absorber of heat. In fact, it comes pretty near holding the record. Its value as a heat absorber is due to its latent heat, that is, the amount of heat necessary to change it from the liquid to the gaseous state.

Ammonia owes its value as a heat absorber (or as a refrigerating medium) to its latent heat, which is the amount of heat necessary to change it from a liquid to a gaseous state.

A boiler filled with steam would absorb very little heat compared to what it would absorb if partly filled with water, and a brine cooler filled with ammonia gas would absorb only a small per cent. of the heat which it would if partly filled with liquid anhydrous ammonia.

If Mr. Reynolds will fill a test flask about half full of liquid anhydrous ammonia and expose it to the air, he will notice that the flask will frost from the bottom up to the liquid level, which goes to prove that the liquid absorbs the heat. For, if the gas absorbed the heat, it would frost from the liquid level to the top.

Now, to return to my expansion valve, only liquid ammonia ever passes through it, in the form of a coarse spray, and such is the case with all the expansion valves with which I have had any experience (with one exception). The exception was in connection with an air-refrigerating machine where the refrigerating agent is not liquefied.

As a matter of fact, I keep my brine cooler two-thirds full of liquid anhydrous ammonia at all times. The expansion valve controls the amount of liquid fed but it has nothing whatever to do with the rate of expansion. That is controlled by the amount of heat supplied or, in other words, by the temperature of the brine, just as the steaming of the boiler is controlled within certain limits by the temperature of the fire and not by the feed pump or injector.

My brine cooler is fitted with gages which enable me to tell to a nicety just how much liquid ammonia I am carrying.

I often shut down with the brine cooler three-fourths full of liquid anhydrous ammonia, and in starting up only open the cold-gas valve between cooler and absorber and run this way until the liquid level in the cooler is somewhat lowered. I have often noticed that when running in this way with the expansion valve closed, the brine cools even faster than after the so called expansion valve is opened.

There has been considerable talk during the past few years about the "flooded system." It seems to me that a brine cooler operated in this way constitutes the important part of an ideal flooded system.

FRANK MIDDLETON.

Sedalia, Mo.

Underground Pipe Covering

Some years ago I was called upon to devise some means of protecting an underground steam pipe similar to that mentioned by W. P. C. in POWER for December 13. The pipe was 4 inches in diameter and carried steam at 90 pounds pressure. The pipe was about 200 feet long and up to the time of my investigation had been laid in a box made of planks and filled with ashes or other material that would form a suitable insulation. Trouble had been experienced and the pipe had to be taken up for repairs about every 5 to 8 months.

At times the trench would nearly fill with water; this caused condensation to take place so rapidly that a very severe water hammer was the result, especially when the steam was shut off, or when first turned on.

After looking the situation over, I selected some old 6-inch wrought-iron pipe with screwed joints. This pipe was connected up and tested with steam at about 20 pounds pressure, which was left on for an hour, so that we could be sure that no leaks existed. We then placed the 4-inch pipe inside the 6-inch and laid it in the box formerly used, packing ashes solidly about the 6-inch pipe. A trench just wide enough to accommodate the box was then made. A space of about 8 inches was left underneath the box, which rested on supports spaced about 10 feet apart.

One end of the 6-inch pipe was closed tightly about the 4-inch and the other end loosely so. This prevented a circulation of the inclosed air and formed a very satisfactory insulation. The entire arrangement proved so effective that I never heard from it afterward.

In many cases of underground steam-

pipe work the trench is dug with a pitch toward one or both ends, for the purpose of draining the water into a catch basin, which is arranged with a float to automatically control a siphon or steam pump to remove the water. In some cases the float is connected to a signal which serves to call the attention of the person who has been assigned to the duty of controlling the water in the basin.

H. S. BROWN.

New York City.

I noticed on the page of "Inquiries of General Interest," in the December 13 issue, a question by W. P. C. in regard to insulation for underground steam pipe.

It is the general practice among steam-distributing companies to insulate the pipe with a 4-inch thick wood covering, the inside diameter of which is 2 inches larger than that of the pipe.

The inside of the covering is lined with tin, and the outside is given a coat of asphaltum and tar paper to make it waterproof. This is laid on about 6 inches of broken stone in a perfectly drained trench, which is back filled with cinders.

If W. P. C. follows the above suggestions he will have a very satisfactory and efficient job. He will also realize a saving in fuel, for the loss by condensation will be less than with his present arrangement.

FRED. GLASS.

Chicago, Ill.

Federal Laws

In the December 6 issue of POWER, F. E. Albrecht cites his experience with license laws and adds that "he wishes he had let license laws alone and not bothered his head about them."

I would like to draw Mr. Albrecht's attention to the first-page editorials of POWER for November 22 and December 13; they might help some. Also, I wish to point out the fact that engineers in other license districts and towns have had much the same experiences before getting satisfactory results with the license laws.

Apparently, if Mr. Albrecht and his associates had turned their efforts and money to use in getting a Federal license law started or passed, they might have secured some benefit for themselves and their Eastern brothers at the same time.

A good Federal law would do away with all conditions such as those of which Mr. Albrecht complains and, in addition, would place all engineers on an equal footing, both East and West.

There is a law providing for Federal inspection of locomotive boilers, up for consideration by Congress now. What were the various engineers' associations doing when that law was being drafted? Why did they not get busy and have that law extended to cover all stationary boilers within the United States and colonies?

Practically the same men could take care of the inspection work, and I am sure that there is greater need of Federal inspection of stationary boilers than there is of locomotive boilers. The latter are all overhauled and practically rebuilt every year, in the railroad shops, while stationary boilers are kept on operation just as long as they will hold steam and water, and are often operated for months at a time without ever being opened. Yet, there are thousands of lives in danger from explosions in stationary plants for every one in danger from locomotive-boiler explosions, to say nothing of the vast amount of property.

I am not decrying the bill; we need it, but it is only half a bill, only a waste of valuable time and money unless it is extended to include stationary boilers and made a partner to a measure providing for the proper examining and licensing of stationary operating engineers.

Why is it that we do not see or hear more about Federal license laws?

I have been talking and advocating them for five years, trying to get engineers and other men interested in pushing a Federal license law. But, while everyone agrees that it is what we should have, none seem to want to start it going or to help start it. Who started the locomotive boiler-inspection law? Locomotives have been operating in this country almost as long as stationary engines with no law to control them except the railroad rules, while the stationary engine has always been more or less controlled for years.

Wake up, brothers, and get to work; look a little further ahead than your own nose. When you think of a license law do not stop with the boundary line of your State, but reach out; try to help the man out West and down South. In other words, work for the good of all the engineers in this country, not for the few located just in your own town or State.

If every engineer in this country will do his share in this, we can have a Federal law so close on the heels of that locomotive boiler-inspection law that it will scare it. Think it over and act.

A. A. BLANCHARD.

Oak Harbor, O.

Boiler and Tube Failures

In reference to the numerous articles on boiler explosions and with especial reference to those on a boiler-tube failure, pages 2128 and 2131, in the issue of November 29, it may be pertinent to inquire whether the reduced thickness from No. 10 gage to nearly 1/32 of an inch at the point of rupture was due to an initial defect in construction, or to internal or external corrosion. If to one or both of the last two, which was the greater inducer, and why? It has been for many years my belief that if we could unite copper with iron and steel after the manner in which gold-plated ware is made on a commercial basis, which I think may be done, the product might be good for boiler shells, tubes, steam and other pipes, etc.

Possibly this might be done to some extent in the manufacture of seamless tubes, and tend to increase the efficiency in economy in steam plants. While the days of the all-copper fire box, staybolts, etc., are doubtlessly past, maybe that copper-plated ones may supersede the ones at present in use. Though much has been said and written by professors and theorists on the forms, construction operation and explosions of boilers and the relative effects of punched, drilled and reamed rivet holes; lap and butt joints, single- double- and triple-riveted, as compared with the initial sheet before being bent and formed, but little has been said of the effects of the strains set up by the forming process. If anything has been said in condemnation of the location of the seams joining the upper to the lower half of the sheets of horizontal boilers, I have yet to learn of it. Why is this seam universally regarded as being the weakest part of the boiler shell situated at a line naturally subjected to the greatest amount of frictional effects by reason of the active elevation of the surface of the water and also the point most susceptible to the effects of corrosion?

Would not these considerations then lead us to the logical conclusion that, if but a single line of joint be used, it should be placed in a position least subject to these effects—at the very bottom of the boiler—even though it would there be subject to strains due to the weight of the water in addition to the pressure to which the upper half of the circumference is subject?

If a diagrammatic chart were constructed of a boiler made practically perfect in all its parts as now constructed and operated; depicting its changes at numerous equidistant points circumferentially and longitudinally; from the first application of heat and at regular points in the increase of the rate of heat absorbed, up to the working pressure desired, when at rest and operating the motor, I think the chart would be curious and, possibly, instructive. If applied also to individual tubes and heads in like manner, probably even still more curious effects would be shown, many parts are fatigued, like overworked men, while others have comparatively easy times.

JOHN W. PAYLER.

Detroit, Mich.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
150 Michigan Avenue, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, April 2, 1908, at the post office at New York, N. Y., under the Act of Congress of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 35,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

PAGE

Power Plant of the Raike Building..... 58
A Slowly Moving Positive Valve Gear... 60
Water Hammer and Boiler Explosions... 62
The Steam Turbine in Germany..... 64
Device for Preventing Smoke..... 66
Notes on Riveting Boiler Plates..... 67
An Investigation of Bearing Metals..... 68
Compression in Steam Engines..... 71
Primer of Electricity..... 74
Water in Transformer Oil..... 75
Elementary Lectures on the Gas Producer 76
A New Diesel Engine in Small Sizes..... 77
The Future of the Gas Engine..... 78

Practical Letters:
Trouble with a Heating Plant.... Simple Method of Binding POWERS ....Two Methods of Facing Belts.... Hot Water Reheater....Patching a Second-hand Boiler....The Way to Do It....Brine Foamed.....79-81

Discussion Letters:
Steam Boiler Economy....Boiler Room Economy .... Boiler Room Emergencies....Trouble with Water Column .... Exhaust Steam Regenerators....Water Gage Connections.... Experience of an Indicator Man.... Installing Globe Valves....Liquid Discharging Device .... The Expansion Valve....Underground Pipe Covering ....Federal Laws....Boiler and Tube Failures 82-86

Editorials 87-88
Boiler Explosion in Pittsfield, Mass..... 89

POWER

Overpressure on an Old Boiler

In the Pittsfield boiler explosion is the first instance of an explosion of a boiler which was entirely under the jurisdiction of the Massachusetts district police, and it should not be difficult to place the responsibility for this calamity.

In all of the preceding explosions since the inspection laws of this State went into effect, the boilers have been insured by some commercial inspection and insurance company, and the State inspectors have had little to do with them beyond the examination of reports filed at the State house.

In this instance the boiler was examined by a State official who fixed its operating conditions. A man also examined by a State official was given permission to operate boilers and engines on the supposition that he was duly qualified for such work.

This safe boiler was put in the hands of the qualified man and exploded, on the very first day of its service, snuffing out the lives of twenty human beings.

It is not known what pressure caused the calamity, nor is it possible to approximately estimate it, but it is probable that it was far in excess of that fixed by the inspector. The boiler may have been safe for the pressure allowed, but it is highly probable that the pressure was carried beyond the safe limit by a misunderstanding on the part of the man of the paramount importance of the fact that safety valves and pressure gages should agree.

Profit Sharing Plan of the Brooklyn Edison Company

The recent action of the Brooklyn Edison Company in announcing a profit-sharing and pension system has evoked both favorable and adverse criticism; the optimist regards it as a substantial recognition of the employee's right to share in the profits of labor, while the pessimist can see in it only a scheme to keep the men in a state of virtual serfdom under the guise of pretended benevolence. In spite of whatever grounds these extremists may find for basing their contentions, the plan is to be commended more than condemned.

The avowed purpose of the plan as set forth in the company's announcement to its employees is "a recognition of faithful and efficient service and the encouragement of thrift and investment in the securities of the company." Reading between the lines shows the first part of this statement to be a purely business proposition; the company in return for a bonus expects to receive better service, to make the employees feel a personal interest in the company, thereby eliminating one great source of waste, and to retain their employees for longer periods of time, in this way doing away with the bother and loss in efficiency through continually breaking in new men.

The terms stipulate that those who have been with the company two full years shall receive a percentage of their wages for 1910 equal to one-fourth of the rate of dividends paid on the capital stock of the company during the past year; those who have been with the company three, four and five years shall receive, respectively, one-half, three-fourths and the full rate of dividend. This money, however, cannot be withdrawn by the employee within three years, except in special cases; but instead is deposited to his credit with the Brooklyn Edison Investment Fund, he receiving only the interest upon the dividend. Expressed in dollars and cents this would be as follows:

Assume that a fireman has been in the employ of the company for three years. His wages amount to $910 per year and if the rate of interest on the capital stock is eight per cent. (a fair estimate based upon the figures of past years), his share of the profits would be $36.40; but as this is turned over to the Investment Fund, he would receive only the interest which, at five per cent., would amount to $1.82 one year from this January. A watch engineer under the same length of service would have $58.24 placed to his credit and would receive $2.91. At the expiration of six years of service the fireman would be entitled to withdraw $163.80 and still have $72.80 to his credit, which latter sum he would receive annually thereafter. This would be equivalent to an increase in weekly wages of $1.40.

Although these figures may appear insignificant, their fairness, after five years of service, cannot be questioned. If a man's labor be considered as part of the working capital of the company, and providing he receives equitable wages, his share in the profits is obviously a percentage of his yearly wages equal to the rate of dividend paid on the capital stock of the company.

Flywheel Rims

It may not be too late to suggest that there is still room for improvement in the design and construction of the rims of large flywheels. That there has been progress in the past ten years is generally admitted, but there still seems to be a lack of knowledge on the part of some builders, of the essential weakness of the old-fashioned joint for wheel rims.

That this weakness is not confined to flange joints is evidenced by the sample of a large wheel on the engine of a plate mill which was examined some years ago and found to have a safety factor of only two. That is, an increase in speed of about 40 per cent. would have wrecked the wheel. This engine and its flywheel were built by a firm of national reputation and were in other respects of a high standard of workmanship, but the keyed joints of the wheel rim had only a small fraction of the strength of the rim itself.

In order to clear up any misunderstanding on this important feature of engine design, it may be well to state a few facts which have been determined partly by calculation but largely by direct experiment on smaller wheels.

A thin, comparatively wide, cast-iron rim such as is used on belt wheels, is subjected when in motion to tension along its circumference caused by the centrifugal force, just as a boiler shell is subjected to tension due to the internal pressure.

If the rim is unrestrained by the arms, as is the case in some wheels having the arms free to slip in the rim sockets, this tension in pounds per square inch of rim section will be expressed very nearly by the fraction, $v^2 \div 10$, for cast iron, where v is the rim velocity in feet per second.

Assuming the tensile strength of soft, gray iron to be 16,000 pounds per square inch, $v^2 \div 10$ would equal 16,000, and v would equal 400 feet per second, the bursting velocity.

Numerous experiments have verified this conclusion and have further shown that in wheels with whole rims, as ordinarily designed, the influence of the arms is negligible. The effect of arms which rigidly connect hub and rim is to restrain the rim from expanding, cause it to assume a wavy outline and to induce contrary bending moments at the arms and at points midway between the arms. This action causes stresses of tension, compression and shear which combine with the tension already existing to produce complicated resultant stresses. These are further complicated by the stretch of the arms themselves and by the initial stresses due to cooling strains. An ordinary cast-iron pulley having six or more arms will, however, burst at about the speed above indicated.

The introduction of rim joints changes all this, especially if the joints are between the arms. The addition of flanges or bosses and the introduction of heavy bolts or links for fastenings very much increase the local centrifugal force and therefore increase the bending moment at that point.

It is as if we had a plate girder, spanning a gap between two abutments and designed to carry a certain uniform load, and should proceed to cut it in two at the center, fasten it together by bolts located near the top flange and then put a large concentrated load at the point of weakness. We would naturally expect failure.

To illustrate the enormous force sometimes exerted by concentrated weights, we may consider a wheel twenty feet in diameter running at two hundred revolutions per minute or about one-half its bursting speed. The centrifugal force of a one-pound bolt in the rim at this speed would be about one hundred and forty pounds. A cast-iron double flange on such a wheel might weigh two or three hundred pounds and would exert a pressure of fifteen or twenty tons tending to rupture the joint.

For the same reason, balance weights inside the rims of high-speed pulleys are always a source of danger.

Experiments have shown that wheels having flange joints between the arms sometimes burst at less than half the speed attained by whole-rim wheels.

Now, whatever factor of safety is adopted in determining the safe speed of such wheels, this fact must be remembered:

A flywheel requires a certain interval of time to attain a dangerous speed and the larger this interval, the better for all parties concerned.

The racing of a flywheel is usually due to temporary disarrangement of the governor and depends upon the difference between the full energy of the steam and the load which the engine happens to be carrying at the time. If the flywheel is so designed that the bursting speed is three times the normal, there will ordinarily be ample time to close the throttle and prevent an accident.

Furthermore, it is known that air resistance and friction are considerable at high speeds and exert a marked retarding effect. If a wheel has radial ribs upon the faces of arms or rim the air resistances may be sufficient to prevent the attainment of dangerous speed.

Granted that any wheel will burst at some speed, it must be admitted that the wider the margin between the normal and the bursting speeds, the less the danger of accident.

It requires less courage to close the throttle when the engineer knows there is a respectable factor of safety in his flywheel.

Graft

The frank expression of such opinions as that of Amos Skeg in our issue of December 20, to the effect that "sales people and not the engineer or the employer are the ones to benefit by a too critical view of what constitutes a bribe," is not calculated to accelerate the movement for the abolition of graft. The picture of an employer conspiring with his engineer to get more out of the seller of supplies than the face of the bill calls for is not flattering to the employer and is degrading to the employee, who, to put it in its most charitable light, has received his master's permission to accept tips like any menial.

Where are the high ideals of the professional engineer?

No Boiler Explosions in Montana

Although last year was one of the most disastrous in the matter of boiler explosions, Montana's record shines out bright and clear, for during the entire twelve months not a single boiler explosion occurred. J. H. Bailey, State boiler inspector, is proud of this record. During the year three inspectors traveled 23,306 miles to examine internally and externally 2021 boilers.

In those inspections 2382 defects were noted, 1819 of which were considered dangerous, and suitable repairs were ordered made. Eleven boilers and seven mud drums were condemned as unfit for further service and pressure was reduced on 43 boilers.

The man who mistakes a mark on the gage glass for the water line, can be classed with the man who knocked the milk pitcher off the table, mistaking it for the cat, or tried to hang his coat on a nail only to find that it was a housefly.

The average man refuses to buy a clay pipe with a piece broken off the stem, but breaks off the stem to suit himself. This seems to be the case with the engineer who buys nicely finished brass unions and mars them all up with a stilson wrench.

Do not be hasty in prophesying failure, as things are sometimes practical that do not look so. It is often easier to make a thing work than to try to convince your boss to the contrary.

The engineer gets into trouble with two kinds of appliances: one is imperfect, and sticks; the other is too perfect, and sticks.

Reliability of both men and machines consists in their working when your back is turned.

Boiler Explosion in Pittsfield, Mass.

By F. L. Johnson

An incorrect steam gage leads to screwing down on the safety valve, causing an overpressure, which blew the boiler into more than fifty pieces, some of them no bigger than a man's hand, and threw pieces of boiler and engine weighing hundreds of pounds an eighth of a mile.

The Morewood Ice Company's plant at Pittsfield, Mass., was the scene of a disastrous boiler explosion at 9:45 on the morning of December 29, when 12 men were instantly killed and 20 or more injured, 5 of whom died later. The boiler was of the locomotive type surmounted by a 10x18-inch slide-valve engine which was scattered with parts of the boiler in all directions.

The barrel of the boiler was 36 inches in diameter, built in two courses of ⅜-inch charcoal-iron plates, and was 7 feet between the heads, in which there were fifty-three 2¼-inch tubes. Both the longitudinal and round-about seams were double riveted. The fire box, water leg and crown sheet were slightly over 5/16 inch thick. The crown sheet was supported by crown bars and the sides were supported by ⅞-inch staybolts, pitched 4⅞ inches.

During its many years of service, the fire-box portion had been subjected to a varied course of repairs, one being a strip of ¼-inch steel plate going around three sides.

As near as can be learned, the boiler was approximately 40 years old and had been in intermittent service in various parts of the State from Holyoke to Pittsfield. It was picked up at a bargain four years ago at Springfield, near where it had passed several years doing duty in a small sawmill and had carried a working pressure of 125 pounds. During the ice harvest the boiler was used from 10 days to two weeks and lay idle the rest of the year. There were in the boiler house when the explosion took place about 20 men, not one of whom is alive to give any information of what was going on immediately before the failure. It is reported that the boiler was inspected last March by one of the Massachusetts State inspectors who ordered some minor repairs and fixed the working pressure at 70 pounds, and ordered the purchase of a new steam gage and safety valve.

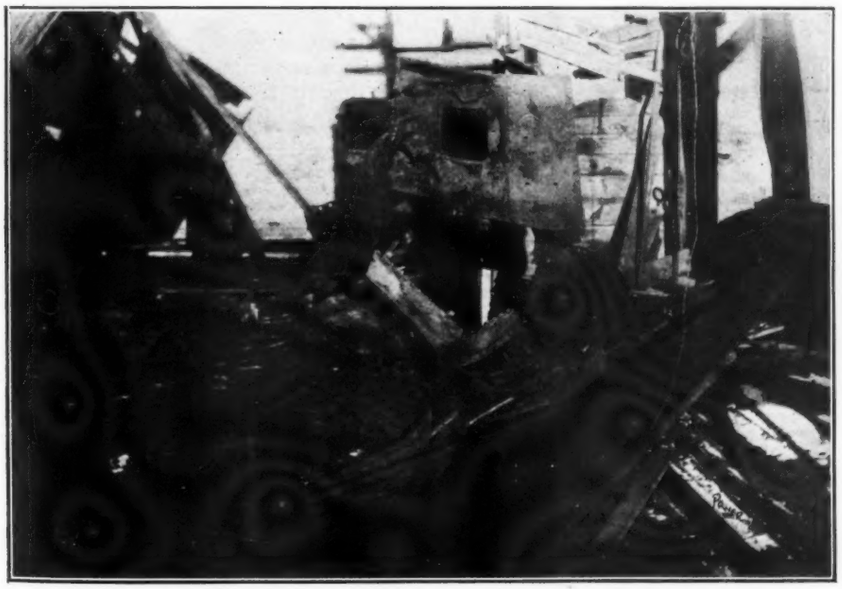


FIG. 1. MAIN PART OF FIRE BOX

In accordance with the orders of the State inspector the repairs and changes suggested when the boiler was inspected in March were made before the boiler was put under steam. These consisted of a new water glass, a ¼-inch steam-gage connection conforming to the rules of the Board of Boiler Rules, a new steam gage and a new safety valve. Also a thorough cleaning of all bricks, dirt and ashes from inside and around the fire box.

Steam was raised for the first time this season on the day before the explosion, and the safety valve blew when the steam gage indicated a pressure of only 35 pounds. The tension on the valve spring was increased and the gage taken to a local plumber for testing and repairs, after which it was replaced on the boiler.

One man who had left the boiler house just before the failure reported that the gage showed a pressure of 40 pounds when he left and that steam was blowing from several places about the boiler.

FIG. 2. CYLINDER OF ENGINE

It was not a lap-seam failure and with the exception of the single-riveted joint at the smoke-box end, nearly all of the ruptures tore through solid metal. It was not a case of tearing along the lines of least resistance but more as if the explosion was caused by a charge of dynamite.

Some slight idea of the force expended may be gathered from a study of the direction of and the distance to which various parts of the boiler and engine were thrown. The fire box was torn from the barrel and, like a pasteboard box, crushed and hurled backward against a corner of one of the ice houses, while the engine cylinder sailed off to one side, landing about 200 yards away on the hill side, dropping the piston and slide valve on the way. One side of the fire box and a part of the head landed diagonally about 100 feet away. The middle course, with rags of iron torn from the fire box, went nearly 500 feet in a direction opposite to that taken by the engine cylinder, cutting off the tops of several trees in its path.

About 50 feet in front of the boiler were two trees growing closely together, between which the flywheel end of the crank shaft dropped on its return course earthward. The other end of the shaft, with the connecting rod and the crosshead from which the piston rod had been pulled, shearing the 2x½-inch steel key, fell about 20 feet to one side. The front

course was torn from the head and fell in several pieces quite near, while the front head went fully 100 feet directly forward.

The safety valve, which was found about 50 feet away, was taken by the chief of police to one of the plants of the Pittsfield Electric Company, where it was subjected to a pressure of 154 pounds per square inch, which failed to open it. No additional pressure was put on the valve at this time. Later it was taken to the laboratory of the Stanley works, where it was subjected to a dead-weight test of 161 pounds without opening. It was finally forced open by the application of a water pressure of 225 pounds after which it popped repeatedly at pressures ranging from 210 to 220 pounds.

While the failure was almost instantaneous in all parts of the boiler, it is probable that the initial rupture started in one of the water-leg sheets where the feed-water pipe entered, as near this point the metal was eaten away to about one-third of its original thickness. There was no evidence of low water and the fusible plug taken from the crown sheet is in good condition. It was a case of overpressure caused by an incorrect steam gage which led to the screwing down on the spring of the safety valve.

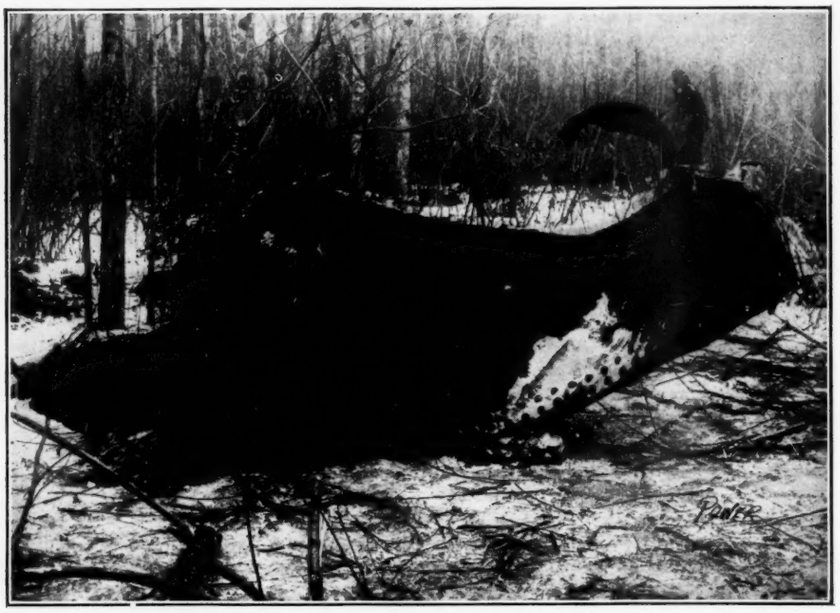


FIG. 3. MIDDLE COURSE THROWN 500 FEET

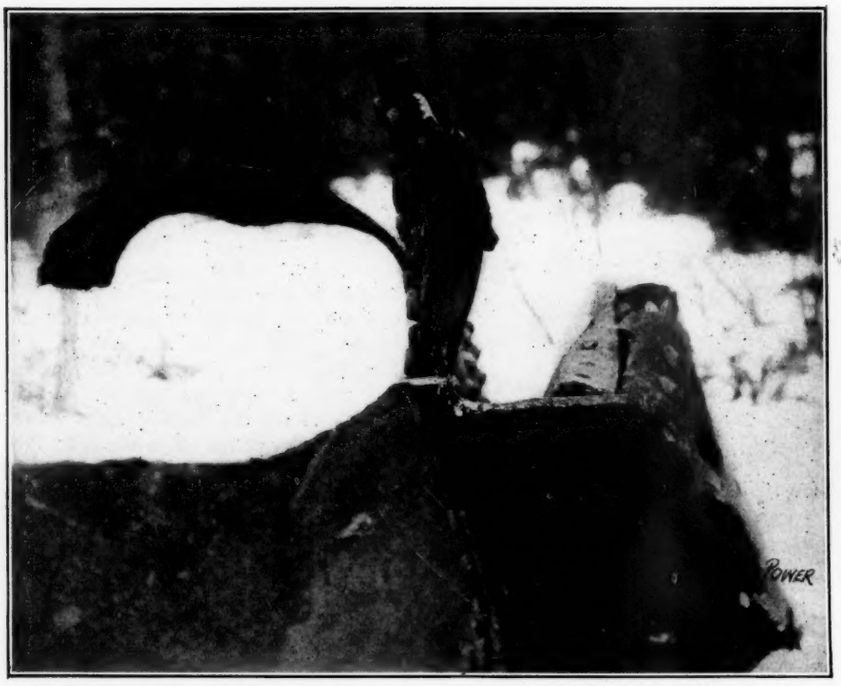


FIG. 4. PART OF MIDDLE COURSE WITH PART OF WATER LEG

Proportion of Nitrogen in Flue Gas

BY JULIAN C. SMALLWOOD

In view of the occasional publication of improbable, if not impossible, results from flue-gas analyses as made from apparatus such as the Orsat, it seems worth while to call attention to the significance of the proportion of nitrogen. The amount of this constituent of flue gas, in the case of coal combustion, is always nearly 80 per cent. if the accompanying results are valid. The reasons for this are as follows:

The proportion, by volume, of the oxygen to the nitrogen in the atmosphere is approximately 21 to 79. If pure carbon were used in the furnace, no matter how much air were admitted, these same proportions of oxygen to nitrogen would be found in the flue gas. For example: if just enough air for complete combustion were used and if, under these circumstances, the combustion were complete, the reaction would be

$$79\ N_2 + 21\ O_2 + 21\ C = 21\ CO_2 + 79\ N_2,$$

the right-hand member representing the flue gas, in which there are twenty-one molecules (that is, volumes) of oxygen, in the CO_2, as in the air.

The effect of the nitrogen, oxygen and hydrogen in the coal actually burned is to alter the proportion of oxygen to nitrogen originally existent in the air. But the amounts of these elements in the coal are small; therefore, the proportion of 21 to 79 is approximately realized in actual flue gas. If anthracite coal is used, the effect of its constituents in altering the proportion is slight; but with bituminous or semi-bituminous coals it is more marked, on account of the comparatively large amounts of hydrogen and oxygen. Part of the hydrogen may be considered to combine with the oxygen of the coal to form water, which does not appear in the flue-gas analysis. What is left of the hydrogen combines with oxygen from the air, and this tends to reduce the proportion of oxygen apparent in the flue gas. The nitrogen in the coal also has this effect, since it increases

FIG. 5. PART OF CRANK SHAFT IN TREE CROTCH

the total nitrogen, but not so much as would superficially appear. Coal containing 2 per cent. by weight of nitrogen would add to the flue gas a very much smaller percentage by volume, nitrogen being a heavy gas. Furthermore, the flue gas is formed by the combination of several pounds of air with each pound of coal; the proportions of the coal's ingredients when in the flue gas are less than when in the coal.

Since the ratio of oxygen to nitrogen remains the same and since the oxygen appearing in CO_2 occupies the same volume as free oxygen, it follows that the percentage of nitrogen as shown by the analysis will be approximately the same as in air; namely, 79. If CO is present, the percentage of nitrogen will be reduced, because this gas occupies twice the volume of the free oxygen entering into its composition. But as the CO is usually only a fraction of 1 per cent., if present at all, its effect to lessen the percentage of nitrogen is not marked. Free hydrogen, on the other hand, is measured as nitrogen and tends to increase its apparent volume, but it, too, is likely to be present in very small quantities.

The foregoing facts may be demonstrated by calculating the reactions for various combustions of a coal high in hydrogen and nitrogen and comparatively low in oxygen, to show the resulting percentage of nitrogen in an extreme case. Such a coal is represented by the following analysis:

Carbon, Per Cent.	Hydrogen, Per Cent.	Nitrogen, Per Cent.	Oxygen, Per Cent.	Sulphur, Per Cent.
80	4.6	2	4.8	1

Following is the flue-gas analysis which theoretically would result from such a coal. The calculations for the reactions neglect the SO_2 from the sulphur, and complete combustion of hydrogen is assumed:

	CO_2, Per Cent.	O_2, Per Cent.	CO, Per Cent.	N_2, Per Cent.
With 50 per cent. excess air	14.3	5.0	0	80.7
With no excess air (complete combustion assumed)	18.7	0	0	81.3
With no excess air (incomplete combustion assumed)	16.8	0.9	1.8	80.5

These results show, as would be expected, that the greater the excess air, the more nearly does the percentage of nitrogen approximate to 79. Also, it may be observed that, although the CO decreases the percentage of nitrogen, the ratio of total oxygen to nitrogen is the same as in the case of complete combustion with the same amount of air. When anthracite coal is used, the percentage of nitrogen is between 79 and 80. It is not likely to exceed 81.5 even in the case of bituminous coals, and every excess of this figure renders the results questionable.

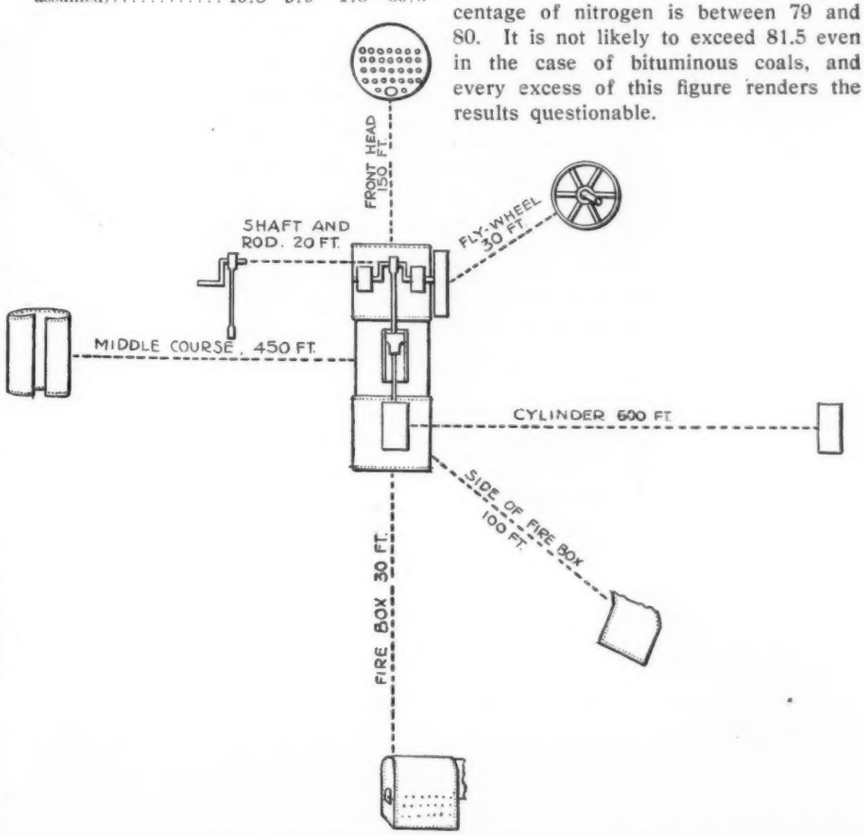

FRONT HEAD 150 FT.
SHAFT AND ROD. 20 FT.
FLY-WHEEL 30 FT.
MIDDLE COURSE. 450 FT.
CYLINDER 600 FT.
SIDE OF FIRE BOX 100 FT.
FIRE BOX 30 FT.

FIG. 7. PATHS TAKEN BY THE VARIOUS BOILER AND ENGINE PARTS

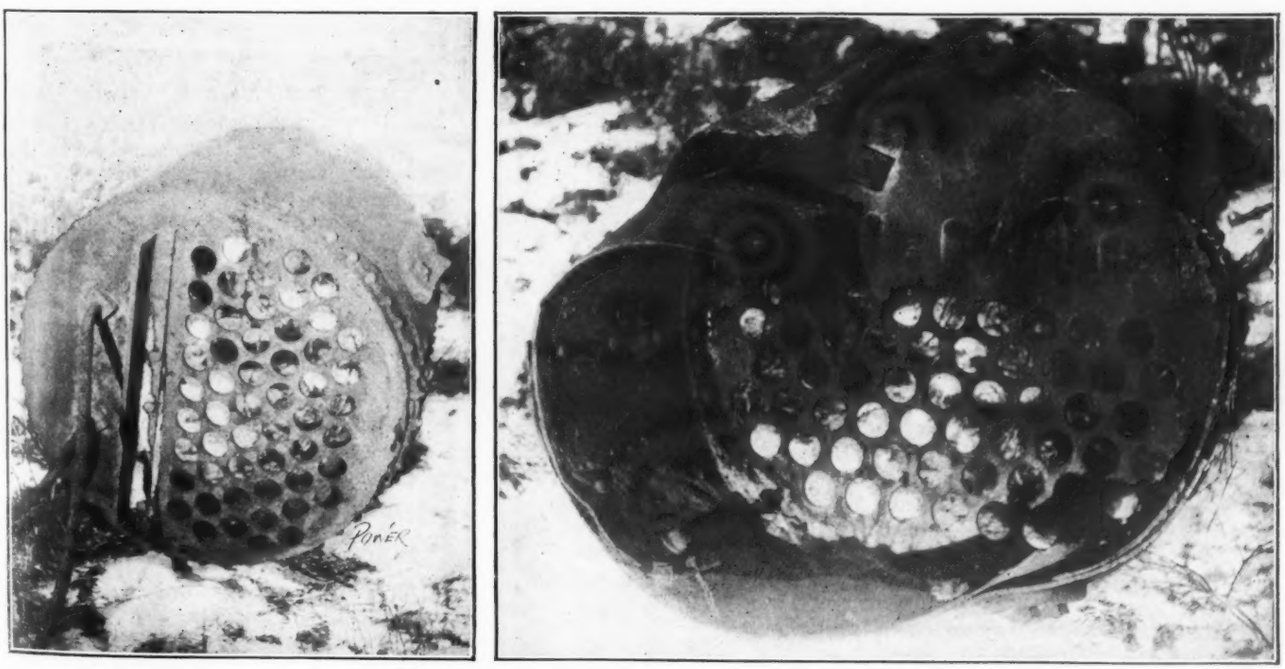


FIG. 6. FRONT AND REAR VIEWS OF FRONT HEAD AND SMOKE BOX

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Compound Gage

What is a compound gage, and for what purpose is it used?

A. C. G.

In a compound gage the dial is graduated to indicate pressures both above and below that of the atmosphere. From the zero mark the numbers read on one side the pressure in pounds above the atmosphere and on the other inches of mercury or pounds pressure below the atmosphere or vacuum. It is used wherever the pressure is liable to be either above or below that of the atmosphere, as is the case of the pressure in the receivers of compound engines.

Most Economical Vacuum

With a compound-condensing engine, how can I tell whether a 25- or a 27-inch vacuum is the more economical?

V. M. E.

By noting the hight at which the governor revolves. Other things being equal, the engine is using the least steam when the governor is highest.

Low Water

What should be done in a case of low water in a boiler carrying 100 pounds pressure?

C. L. W.

Smother the fire immediately with green coal. Close the ashpit doors. Open the damper, allowing cool air to draw through the furnace and tubes. Leave the engine running until pressure is reduced to the lowest possible point. If the feed pump is running let it run as long as it will. When the pressure will no longer run the engine or pump, it may be still further reduced by opening the gage cocks and the water-column drain valve. When the pressure has been reduced to near the atmosphere, water may be let in to the usual hight, and a search made for leaks or signs of overheating. If none appear, the fire may be started and the boiler put into service.

Incrustation and Corrosion

What is the difference between the corrosion and incrustation of steam boilers?

C. A. I.

Corrosion is the rusting or eating away of the iron or steel of the boiler, either internally or externally. It may be caused by air, water, acid, sulphur, etc. Incrustation is the covering of the surface with the solid matter left behind when the water passes away as steam and occurs only on the inside of the boiler.

Initial Condensation

What is initial condensation?

I. E. C.

When steam enters the cylinder at the beginning of the stroke it comes in contact with the piston, cylinder head and wall, which are cooler than the entering steam and as steam cannot exist in contact with anything cooler than itself, a part of it is condensed. Initial means at the beginning and as the steam is condensed at the beginning of the stroke, it is called initial condensation.

Rotary Engine

What is a rotary engine?

R. E.

A rotary engine is one having no reciprocating parts, the force of the steam being expended directly in producing rotation without the intervention of piston, connecting rod or crank.

Vacuum Breaker

What is a vacuum breaker, and for what purpose is it used?

C. V. D.

A vacuum breaker is an appliance attached to a jet condenser which automatically admits air to the exhaust pipe or condensing chamber of a condensing engine when water rises above a predeterminated hight in the system, destroying the vacuum and preventing water from entering the cylinder.

Complete Combustion

What conditions will cause practically complete combustion in a boiler furnace?

C. F. C.

There must be a high-furnace temperature, sufficient air intimately mixed with the fuel and distilled gases and room enough for the gases to burn without the flame coming in contact with the heating surfaces.

Loop in Steam Gage Pipe

Why is there always a loop in the pipe connecting a steam gage to its boiler?

L. S. G.

It is placed there to form a trap for water so that steam may not come in contact with the spring and by its heat affect its temper.

Lead Joints in Water Pipe

How are the lead joints in cast-iron water pipe made?

J. W. P.

The lengths of pipe are laid in position with the small or spigot end of one length accurately centered in the large or bell end of the next and held central by blocks of wood underneath and at the sides.

The annular space between the bell and spigot is then filled with tarred rope yarn which is calked in until the bell end is filled to within a half inch of the end.

A dam is made around the joint, usually a strip of tuck packing held by a clamp and melted lead poured into the space between the dam and the packing. Afterward, the lead is solidly calked. The packing makes a water-tight joint and the lead holds the packing in place as would a gland.

Compound Engine Cylinder Ratio

How can the proper cylinder ratio in a compound engine be found when the steam pressure, vacuum and load are known?

C. E. R.

The proper cylinder ratio in compound engines is a debatable question. A ratio which will give an equal number of expansions in each cylinder is found by assuming the probable initial pressure in the high-pressure cylinder and the terminal pressure in the low; then divide the initial pressure by the terminal and the square root of the quotient will be the proper cylinder ratio.

The life of the rubber hose of the flue blower can often be doubled by arranging the steam pipes so as to avoid short bends of the hose, also by remembering to turn on the steam before uncoiling the hose, as it is stiff and brittle when cold.

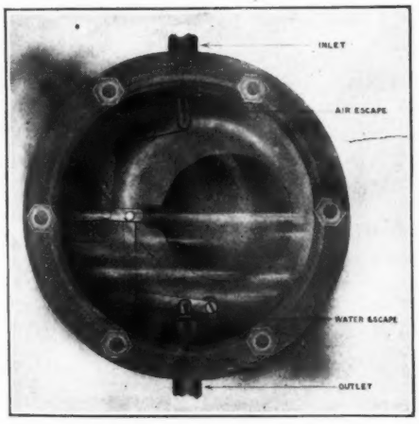
New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Combination Air and Water Trap

This trap is designed to handle both water and air from steam pipes, radiators, separators, etc. The trap does away with air cocks and air valves, and the escape of air is automatically taken care of. The accompanying illustration shows the interior construction of the trap, which consists of a casing, two needle valves, a float and lever connection.

The trap operates as follows: The trap being attached and the connection opened, the float is at the bottom of the chamber with the air escape open and the water escape closed. The pressure will then rise in the trap, and should the system be air bound the air will escape through the air valve. The steam will follow, and with it the water, which will



SECTIONAL VIEW THROUGH TRAP

accumulate in the bottom of the float chamber, raise the float and gradually close the air escape. Further raising of the float after the air escape is closed will open the water escape and water will be discharged.

To compel the operation of the trap at the neutral point when both valves are closed, the bottom valve and its seat are not ground to a tight fit, thus permitting enough water to escape to insure continuous action of the trap when but very little steam is being condensed in the piping or other apparatus to which the trap is attached. The capacity of this trap is large, and it will successfully pass quantities of dirt and scale, due to the construction of the water valve, which is without wings or guides, and the seat, which has but small bearing surface and is removable.

This trap is made by the Atkins Brothers Company, Springfield, Mass.

Rolin Adjustable Interchangeable Grate Bar

This grate is so designed that four different air spaces can be obtained with the same set of bars. It consists of three revolving bearing bars, one of which is shown in Fig. 1. This bar is made with four sets of projections, each set being differently spaced. On these revolving bars, the surface bars, Fig. 2, are placed and as the end and central bearing surfaces are made tapering, the surface bar will fit into the slots of the revolving bar to a greater or less degree according to the spacing of the projections. Fig. 4 shows how this is done.

Whenever it is found desirable to change the size of coal and to decrease or increase the width or the air space between the bars, it is only necessary to lift the grate bars from the grooves they are resting in, and turn the bearing bars until the desired groups are on top, when the grate bars are replaced. By this means a ¼-inch air space can be obtained for barley or rice coal; ⅜-inch air space for pea or stove coal; ½-inch for nut coal, and ⅝-inch, ¾-inch and ⅞-inch for all grades of bituminous coal.

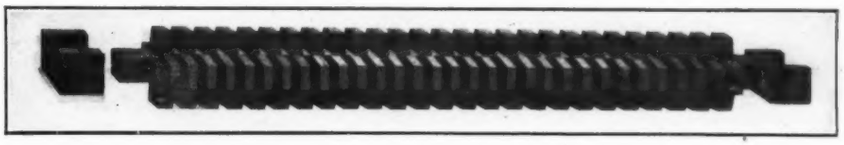


FIG. 1. SECTION OF BEARING BAR

FIG. 2. SECTION OF GRATE BAR

Fig. 3 shows the grate in position under a boiler.

The surface bars are the only part that

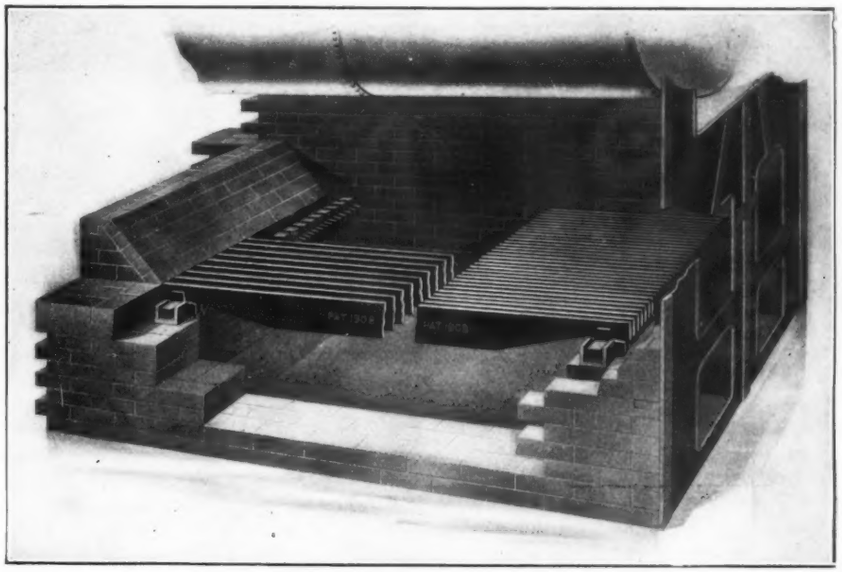


FIG. 3. GRATE BARS IN POSITION UNDER A BOILER

will require renewal, as the bearing bars should last the life of the boiler. This grate is made by the Standard Grate Company, 1213 Filbert street, Philadelphia, Penn.

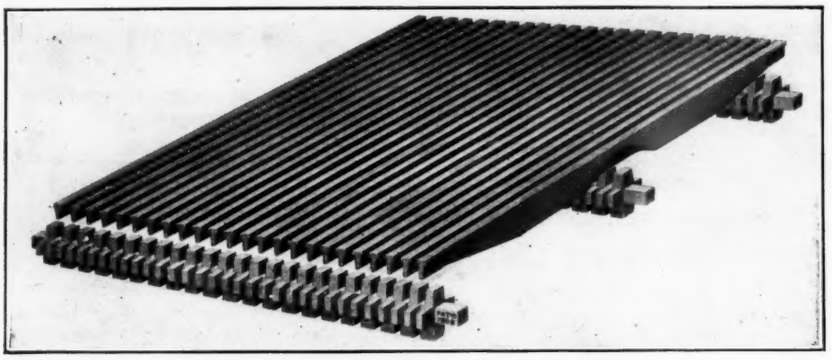
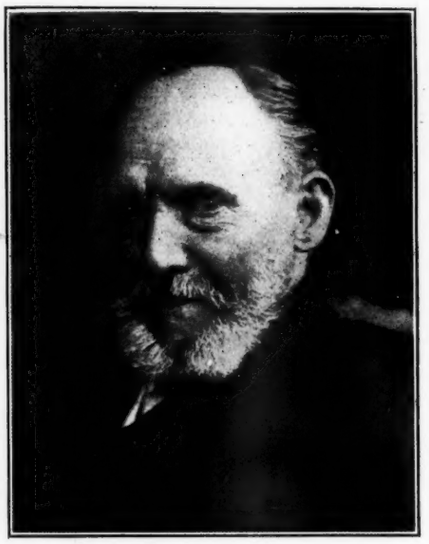


FIG. 4. SURFACE BARS AS SPACED BY THE BEARING BARS

OBITUARY

With Geheimen Kommerzienrat Dr. Ing. h.c. Rudolf Ernst Wolf, of Madgeburg, passed away on November 20, 1910, one of the most important and sympathetic personalities in German industry.

He was born July 26, 1831, the son of Wilhelm Wolf, professor in the Madgeburg Gymnasium. His father intended to give him a university education, but this did not suit the boy's inclinations, and his proficiency in ancient languages left so much to be desired that his father came to doubt whether he was able to study at all. "I don't want to," the lad replied, "I wish to become a machinist." Such a desire was then unheard of in educated circles, since the "black trade" was not considered respectable. But after he had delivered his mind, the parental opposition was soon overcome, and Wolf entered, April 12, 1847, the Maschinenfabrik Buckau as a simple apprentice. After two and a half years of practical instruction in this old-time shop which has given their rudinentary knowledge to so many able engineers, he attended, from October, 1850, to October, 1852, the provincial trade school at Halberstadt. After that he found a place in the Wöhlertschen Maschinenfabrik, of Berlin, where, under the leadership of H. Gruson, the then director of the firm and later founder of the celebrated Grusonwerk in Madgeburg, he was occupied especially in building locomotives. In 1855 he entered the factory of G. Kuhn in Stuttgart-Berg, where at the youthful age of 24 years he filled the office of chief engineer. Here for six years he was engaged in various kinds of work, till he decided to start a factory for himself, since he felt that he had sufficient force and experience to stand on his own feet. On June 15, 1862, he began work in the machine and boiler shop which he principles of construction were original had erected at Buckau, and from the beginning constructed his locomobiles (portable steam engines), whose fundamental with him. They contained removable tubular boilers with cylindrical fire boxes; the working cylinders were live-steam jacketed and connected with the steam dome itself. Thus he was the founder of modern German locomobile construction and developed the engine to its present important position. Among the radical improvements which he introduced were the method of compounding and the use of highly superheated steam.



RUDOLF ERNST WOLF

R. Wolf had early recognized the importance of specialization in machine construction, and had therefore made his shop a special one for locomobiles and locomobile boilers. The greatest possible simplicity of organization and working methods, with concentration of all mental, manual and machine forces upon a single object, enabled him soon to turn out engines of high economic and constructive perfection. Already at the locomobile competitions at Madgeburg in 1880 and at Berlin in 1883, those of Wolf surpassed others, including the English ones. Today Wolf locomobiles show as good economy as eight pounds of coal per effective horsepower-hour.

Among the various products that, during its long existence, have been turned out by the Wolf shop, are rotary pumps and screw propellers, known as Buckau screws and intended for river steamers. The line of threshing-machine locomobiles has been supplemented by threshers themselves.

With Wolf appliances there have been drilled the deepest bore holes in the earth, those of Schladebach in the Saxon province, and of Paruschowitz in upper Silesia, which are 1748.4 and 2002 meters deep. Wolf has also been building stationary boilers and engines and machinery for a variety of industrial purposes.

In 1862, Wolf began with six workmen, and three officials, and built an 8-horsepower locomobile of six atmospheres working pressure, which did forty years' good service and now stands in the technical museum at Munich. Today the Wolf Works employ 3300 officials and workmen, turning out a large number of locomobiles, various in form and size, up to more than 800 effective horsepower and as high as 15 atmospheres working pressure. Beside the old works in Buckau, a new plant has been erected at Madgeburg-Salbke.

Wolf was not only a fine engineer, but a good salesman and a competent organizer. He understood the work of the shop from his own experience and could direct its details with great sagacity. He was popular with his men and solicitous for their welfare. In respect to pensions and various other means of social benefit among them, he far exceeded the requirements of the paternal German laws and long anticipated them. He was a man of public spirit and activity, and received official honors.

Edwin Ford, engineer of the Harlem hospital in Brooklyn, recently passed away. Mr. Ford was past financial secretary of Robert Fulton Association No. 57, National Association of Stationary Engineers, also member of the Municipal Engineers Local No. 319, International Union of Steam Engineers, and past senior warden of Washington Lodge No. 1, Free and Accepted Masons. He was a hard worker for the engineer and seemed to take great pleasure in doing anything within his power to aid the cause.

PERSONAL

John I. Rogers announces that having resigned one year ago from the Midvale Steel Company, of Philadelphia, to take up professional practice, he has since that time engaged in consultation and design, and has now opened a New York office at 165 Broadway. He will make a spe-

cialty of the design and operation of the most modern plants, furnaces and machinery for steam hammer, hydraulic press and drop forging; tire, wheel and other special rolling; hot- and cold-metal working; machine shops and power plants, iron and steel manufacture.

As a result of a Civil Service rule recently inaugurated in Kansas City, E. H. Lane was appointed a member of the board of examining engineers.

NEW PUBLICATIONS

Next best to knowing a thing one's self is to know where to find it. Next best to being able to retain in one's memory all the data and information which come to one's attention is to put it where it can be found. Many engineers keep card indexes of such data, and Edward Wray has conceived the idea of compiling such information as is likely to be of value to engineers and issuing it upon leaves of the standard 3x5 size, printed upon one side only, for filing in a standard index card set. He has associated with him a dozen editors expert in different lines, and issues the sets monthly in a little cover under the name of *Data*. The publication office is at 92 La Salle street, Chicago.

Will Hold Convention Soon

The Institute of Operating Engineers has created a renewed interest in its work by the issuing of the prospectus containing the proposed plan and scope of its work. Several branches are now in process of formation throughout the country and the work has already been adopted in the extension courses at Teachers College, Columbia University. A working agreement has been entered into between the Institute and the Williamson Free Trade School, whereby the graduates of the latter will receive a certificate of the journeyman grade in the Institute of Operating Engineers. Employers are also getting interested in the institute to such an extent that over seven desirable positions have been offered its members. Prominent educators who are interested in industrial education are taking great interest in the work of the Institute of Operating Engineers and are lending their aid and counsel in its formaiton. It is expected that the first convention will be announced in the very near future.

An industrial exposition to commemorate the fiftieth anniversary of the kingdom of Italy will be opened at Turin, in April of next year. It is situated on the outskirts of the city on both sides of the River Po and includes an area of a million square meters, of which 280 square meters will be covered by buildings, making it one of the largest expositions yet held.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

GASOLENE ENGINE. George C. Fain, Bakersfield, Cal. 978,867.

EXPLOSION ENGINE. Guy R. Price, Detroit, Mich. 978,936.

INTERNAL COMBUSTION ENGINE. Arthur H. Webber, Boston, Mass. 978,969.

TWO-CYCLE EXPLOSION ENGINE. Henry R. Sieverkropp, Davenport, Iowa. 979,040.

SINUSOIDAL WAVE-CURRENT APPARATUS. Fred Cedergren, Hammond, Ind., assignor of one-half to Frank S. Betz, Hammond, Ind. 979,060.

FOUR-CYCLE INTERNAL COMBUSTION ENGINE. Robert Miller, New York, N. Y. 979,082.

WIND MOTOR. John Scheubeck, Chicago, Ill. 979,098.

ROTARY ENGINE. Daniel E. Cota, Boston, Mass., assignor of one-half to Jacob Fischer, Boston, Mass. 979,262.

CURRENT MOTOR. Herbert S. McKague, and Axle Robert Johnson, Altoona, Penn. 979,320.

PRIME MOVER. Frank J. Miner, Detroit, Mich., assignor to Miner Engineering Company, Detroit, Mich., a Corporation of Michigan. 979,323.

INTERNAL COMBUSTION ENGINE. Jas. A. Viele, Warren, Penn. 979,359

BOILERS, FURNACES AND GAS PRODUCERS

STEAM BOILER. John A. Doarnberger, Roanoke, Va. 979,135.

STEAM GENERATOR. Robert L. Thompson, Elgin, Ill. 979,356.

POWER-PLANT AUXILIARIES AND APPLIANCES

BOILER CLEANER. Leo Jno. Bayer, St. Louis, Mo. 978,830.

GAGE. Frederick C. Blanchard, Bridgeport, Conn., assignor to the Ashcroft Manufacturing Company, Bridgeport, Conn., a Corporation of Connecticut. 978,833.

STEAM TRAP. John M. Burby, Astoria, N. Y., assignor of one-half to Fritz Muser, Chicago, Ill. 978,842.

HYDROCARBON BURNER. William Dietz, Cement, Tex. 978,860.

FLEXIBLE PIPE JOINT. Warren A. Greenlaw, Melrose Highlands, Mass., assignor to the Greenlaw Manufacturing Company, Boston, Mass., a Corporation of Maine. 978,876.

PIPE HANGER. William H. Mack, New York, N. Y. 978,912.

FURNACE ARCH. William McClave, Scranton, Penn., asignor to McClave-Brooks Company, Scranton, Penn., a Corporation of Pennsylvania. 978,917.

VALVE. Edward O'Malley, Jackson, Tenn., assignor, by direct and mesne assignments, to O'Malley-Beare Valve Company, Chicago, Ill., a Corporation of Delaware. 978,929.

VALVE. Edward O'Malley, Jackson, Tenn., assignor by direct and mesne assignments, to O'Malley-Beare Valve Company, Chicago, Ill., a Corporation of Delaware. 978,930.

HIGH- AND LOW-WATER ALARM. Chas. Brent, Brandon, Manitoba, Canada. 978,983.

COOLING TOWER. Edwin Burhorn, Hoboken, N. J. 978,986.

STEAM BOILER SUPERHEATER. Francis J. Cole, New York, N. Y. 978,987.

VALVE GEAR. Thomas Hall, Ridgway, Penn., asignor to Ridgway Dynamo and Engine Company, Ridgway, Penn. 979,002.

VALVE-SEATING ATTACHMENT. James M. Gibbs, Santa Ana, Cal., assignor of one-half to George E. Powell, Santa Ana, Cal. 979,068.

DRAFT REGULATOR. Frank M. Heath, Portland, Ore. 979,069.

ENGINE VALVE. Joseph Rothchild, New York, N. Y. 979,097.

HAMMER FLUE CLEANER. William J. Baker, Oswego, N. Y., assignor of one-half to Lewis G. Gridley, Oswego, N. Y. 979,121.

STEAM TRAP. Mathew J. Konold, Pittsburg, Penn. 979,172.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

When you were a small boy did you ever go swimming with the other "kids" in some fresh-water pond and, when emerging, find a big, black, ugly looking leech fastened onto you?

"Blood-suckers" we used to call them and we remember that they were about as repulsive a worm as ever made a small boy shiver.

Compared with them a mosquito is a respectable sort of parasite. He, at least, comes at you in a business way. You know which is head and which is tail, and that is more than can be said of your leech.

There are leeches in the business world and, after their fashion, they are quite as ugly and quite as repulsive and, when allowed to get busy, quite as destructive as the old original "blood-sucker."

Their first business in life is to remain unnoticed. Nature seems to have provided them with the instinct that makes them efface themselves as much as possible.

Their next business is to find some big and conspicuous concern manufacturing some conspicuously good article and to fasten onto them for reputation.

Their third business is to find the "easy marks" who will provide their nourishment.

These leeches of the business world are better known to you and us as "substitutors."

Do you know that there are large manufacturing concerns in this country whose whole business is to turn out substitutes for well known, trade-marked brands of goods?

Imagine it—big, wide-open *counterfeiting* factories!

Can you think of anything more crooked and despicable than that?

Yet these industries are made possible because there are enough dishonest dealers in the country to take their goods and enough indiscriminating buyers to accept the counterfeits.

Take it right in your own business, for instance—say some-engine room supply such as grease, oil or packing.

The fake manufacturer's agent says to the dealer, "Here, Mr. Man, you are selling so many pounds of Smith's Packing (mentioning a well known, old established, thoroughly advertised brand), and you are getting about 20 per cent. profit on it. Now, look at this stuff. Same trade-mark, nearly, isn't it? Same kind of a box; same stuff to all intents and purposes, what? Well, I'll sell you this so that you can clean up 35 per cent. on it and nobody will be the wiser."

The dealer can't resist the temptation or doesn't want to. Next time you send for Smith's Packing you get the substitute, and because you don't investigate the name and trade-mark closely enough you accept it as the real thing.

You use it and the next thing you know you find the stuffing box leaking badly. Out comes the offending packing and from that day on Smith's Packing is on your black list.

Unless he hears of your particular case Smith has no come-back—no chance to "show" you—no square deal.

Unconsciously, you are a party to the fraud.

Moreover, in the long run, you are the victim. You put up your good money or recommend that your concern put it up, and you get an inferior article, one which doesn't give the results you expected or one which actually works harm.

These business leeches have no reputation to live up to. They create nothing, they build up nothing. They are destroyers. Their whole function in life is to sustain themselves on a big manufacturer's reputation and a buyer's credulity, through a dealer's avariciousness.

The manufacturer who is everlastingly printing his claims—advertising—must live up to them, deliver the goods, or fail.

Your safeguard in buying is the trade-marked, advertised article.

But, when you buy, *get what you ask for.*

In your hands lies the remedy for the whole rotten practice.

Exercise your prerogative *every time.*

BUSINESS ITEMS

The Vilter Manufacturing Company, 854 Clinton street, Milwaukee, Wis., reports 11 recent sales of Vilter Corliss engines and 19 refrigerating plants.

The Boston Elevated Railway, of Boston, Mass., recently placed an order with the Westinghouse Machine Company, of Pittsburg, Penn., for seven stokers to replace some old equipment at its Charlestown and Lincoln Wharf stations.

W. A. Sharp, who has been actively connected with engineering interests in Chicago for the past 20 years, has opened offices in the Boston block, Minneapolis, from where he will handle, in connection with other interests, the Northwestern business of the Murphy Iron Works, of Detroit, having charge in that territory of the sale and installation of the Murphy automatic furnace.

The Westinghouse Machine Company has just received an order from the Suburban Gas and Electric Company, of Pottstown, Penn., for one 625-kilowatt high-pressure turbine operating between 150 pounds steam pressure and a 28-inch vacuum. The Westinghouse Electric and Manufacturing Company will furnish a 2300-volt, three-phase, 60-cycle alternating-current generator to go with the turbine. The new equipment will generate energy for light and power service.

Lockwood, Greene & Co., engineers of Boston, are just completing plans for a new fine lawn mill, which is to be located in or near Greeneville, S. C. Final decision has not yet been made as to the exact site. The plant will consist of a two-story spinning mill and a one-story sawtooth weave shed. The machinery will be furnished by New England machinery manufacturers who are interested in the project, and the entire plant will be electrically driven, about 1500 horsepower being required.

The Ocoee Construction Company, of Ocoee, Tenn., has placed an order with the Westinghouse Electric and Manufacturing Company, of Pittsburg, Penn., for four 3750-kva., 2300-volt, three-phase, 60-cycle, 360 revolutions per minute, water-wheel type generators; four 3750-kva., three-phase, oil-insulated, water-cooled transformers; two 120-kilowatt motor-generator sets, and a 14-panel switchboard. The waterwheels will be furnished by S. Morgan Smith, York, Penn., and will have a maximum capacity of 5400 horsepower each. The power generated will be used for the electrical railways in and near Chattanooga. J. G. White & Co. are the engineers on the work.

The offices of the Best Manufacturing Company are now located at its new plant at Oakmont, Penn. The new plant increases its capacity more than double. The concentration of departments, the modern equipment and the unexcelled facilities for handling enable it to render the best possible service as to materials, workmanship and prompt shipments. The iron foundry is newly equipped throughout with the latest apparatus, including a complete line of power-molding machines ranging from small squeezers to the largest jarring machines, and adapted for all classes of work. The capacity is 90 tons per day, with facilities for handling castings weighing 50 tons each. It will carry a large stock of valves, fittings and flanges (both full size and reducing) and pipe.

NEW EQUIPMENT

Brandon, Man., will extend its water system.

Winnipeg, Man., will buy a number of water meters.

Dundas, Ont., will install a hydroelectric station.

Hearne, Tex., voted issuance of bonds for waterworks.

Oak Bay, B. C., will install a new waterworks system.

Barrie, Ont., will equip a hydroelectric power station.

Brockville, Ont., will equip a hydroelectric power station.

Harrison, Ont., will spend $35,000 on new waterworks system.

Portsmouth, Ohio, will build new waterworks to cost $100,000.

Lethbridge, Alberta, will spend $700,000 on new waterworks system.

Victoria, B. C., will spend $25,000 for new electrical equipment.

Adel, Ga., will install a new Corliss engine in the electric plant.

Berlin, Ont., will spend $50,000 for new electric-lighting equipment.

The Sidney Blumenthal Company, Shelton, Conn., will install a boiler.

Burnaby, B. C., will install a complete waterworks pumping plant.

Fort William, Ont., will spend $65,000 for new waterworks equipment.

W. H. Morrison & Co. will erect a 40-ton ice plant at San Benito, Tex.

The city of Ellinsburg, Wash., has issued $300,000 bonds for waterworks.

Strathroy, Ont., will improve its electric lighting and waterworks systems.

Bonds have been voted for a waterworks and electric plant, at Giltner, Neb.

The Crystal Ice Company, Marietta, Ohio, will enlarge its cold-storage plant.

H. A. Carter, Melrose, Mass., is in the market for a small gasolene engine.

The French Worsted Company, Woonsocket, R. I., will install a new generator.

Sam Blank, of Valley City, N. D., will erect a two-story cold-storage plant.

Montreal, Canada, will spend about $300,000 for auxiliary pumping machinery.

New machinery will be installed in the electric-light plant at Wakefield, Mass.

Leavenworth, Wash., will vote on the issuing of $45,000 bonds for waterworks.

The city of Brawley, Cal., will install a municipal water system to cost $30,000.

Western Packing Company, Denver, Colo., is in the market for an air compressor.

F. P. Beaver, Dayton, Ohio, is having plans made for a power plant to cost $100,000.

The Stayton (Ore.) Electric Light Company has purchased site for a power plant.

The Oregon Power Company, Eugene, Ore., will build a $1,000,000 hydroelectric plant.

Smiths Falls, Ont., will purchase a pump and turbine water wheel for pumping station.

The city of Albertville, Ala., will vote on issuance of $7000 bonds for an electric plant.

The Citizens Heat and Light Company, Elwood, Ind., will build an artificial gas plant.

The electric-light plant, at Orleans, Neb., was wrecked by an explosion. Will be rebuilt.

The Anderson-Tulley Lumber Company, Memphis, Tenn., will install a Corliss engine.

The Sandoval (Ill.) Zinc Company is contemplating installing an electric-light plant.

The Pawtucket (R. I.) Electric Company is doubling the capacity of its power houses.

John I. Moore has been granted a franchise to erect an electric-light plant at Berthold, N. D.

Armour & Co., of Chicago, will establish a $75,000 cold-storage plant at Chattanooga, Tenn.

The Du Pont Powder Company, Wilmington, Del., will double the size of its power plant.

The city of Greenville, Tex., voted to issue $50,000 bonds for the construction of waterworks.

The town of North Mankato, Minn., will vote on a bond issue of $20,000 for waterworks.

Napoleonville, La., will install a new pump at its waterworks and make other improvements.

The Port Arthur (Tex.) Water Company contemplates the erection of an additional building and the installation of a 50-ton ice plant.

The Santa Barbara (Cal.) Gas and Electric Company will build an addition to its power house.

The Commonwealth Shoe and Leather Company, Whitman, Mass., will install a steam engine.

The Yucaipa (Cal.) Land and Water Company will make improvements in its water system.

The Portland (Ore.) Railway, Light and Power Company has filed plans for a new substation.

The Consumers Gas Company, Toronto, Ont., will build a governor house to cost $14,000.

The city of Norwich, Conn., will need additional equipment for the municipal electric-light plant.

George Wingfield, Winnemucca, Nev., will build a large hydroelectric plant on the Humboldt river.

The Fayette Lighting Company, Lexington, Ky., is having plans prepared for electric power plant.

The C. Shenkberg Company, Sioux Falls, Iowa, has plans for the construction of a power plant.

The Cremo Brewing Company, New Britain, Conn., will build an addition to its cold-storage building.

The Stayton (Ore.) Electric Light Company will build a hydroelectric plant on the Santian river.

The city of Hanford, Cal., contemplates the installation of a municipal sewer system to cost $100,000.

The city of Santa Ana, Cal., will vote on the issuance of $35,000 bonds for new pumping equipment.

The citizens of Albertville, Ala., will vote on the issuance of $7000 bonds for an electric-light plant.

The city of Hartford, Conn., will erect a technical high school and will require boilers, engine and pump.

Jos. W. Bancroft & Sons, Wilmington, Del., will shortly make extensive additions to their power equipment.

The Valley Development Company, Chehalis, Wash., is having plans prepared for a new power plant.

The Canadian Fishing Company, Vancouver,

B. C., will spend $150,000 for machinery for cold-storage plant.

The Jacksonville (Fla.) Electric Company is planning the erection of a new power house on Riverside avenue.

Pomona College, Claremont, Cal., will increase the capacity of its power plant and erect a steam laundry.

The Dominion Power and Transmission Company will spend $100,000 equipping a new substation in Hamilton.

The citizens of Coggon, Iowa, voted a special tax for the erection and maintenance of an electric-light plant.

The Los Angeles (Cal.) Railway Company is building a substation at Ardmore avenue and San Marino street.

The Lyon Metallic Manufacturing Company, Aurora, Ill., will install a new generating plant in the spring.

The city of Horton, Kan., is contemplating the installation of an electric-light plant. B. B. Morris, city clerk.

J. C. Parker, Sons & Co., New Castle, Del., is remodeling and making additions to its factory and power plant.

Burlington, Vt., has voted to issue $53,000 bonds for improving and extending its municipal electric-light plant.

The Amador Mines, Power and Water Company, Jackson, Cal., will build a 2000-horsepower hydroelectric plant.

The St. Louis & Suburban Railway Company is preparing to erect a power plant at Reeb station, St. Louis, Mo.

The Ramona Power and Irrigating Company, Riverside, Cal., will build a power plant in the San Jacinto mountains.

It is said the Port Arthur (Tex.) Water Company is contemplating increasing the output of its electric-light plant.

The W. W. Windle Wool Scouring Company, Millbury, Mass., contemplates installing electric motors in its plant.

Geo. D. Shearer, San Rafael, Cal., has been granted a franchise to construct and operate an electric street-car system.

The city of Fergus Falls, Minn., is considering the erection of a steam turbine or gas plant for the lighting system.

The city of Waupaca, Wis., will buy power equipment for a new high school, including high-speed engines, motors, etc.

The Telluride Association, Payette, Idaho, will build a hydroelectric plant on Snake river, to cost about $2,000,000.

Brown Valley, Minn., will vote on the question of issuing $10,000 bonds for the installation of an electric-light plant.

Plans are being considered to extend the municipal electric-light plant at St. Joseph, Mo., at a cost of about $250,000.

The Los Angeles (Cal.) Gas and Electric Corporation is planning for the erection of additional buildings to its plant.

The Tucannon Valley Produce Company, Pomeroy, Wash., is considering the erection of a cannery and cold-storage plant.

The Hall Printing Press Company, Dunellen, N. J., intends to install individual motors to operate its heavier machine tools.

The Minnesota Canal Power Company, of Duluth, Minn., is planning to construct an 80,000-horsepower electric power plant.

The Idaho Consolidated Power Company, American Falls, Idaho, is to increase its plant from 3000 to 30,000 horsepower.

The Massachusetts Cotton Mills, Lowell, Mass., will erect a large boiler house and coal pocket and two dye-house additions.

The Berlin (Wis.) Brewing Company will remodel its plant and purchase new power equipment, including engines and boilers.

The Green River Hot Springs Company, North Yakima, Wash., which is to build a $50,000 hotel, will also build a power house.

The Nacogdoches (Tex.) Ice and Cold Storage Company has plans completed for two additional buildings, a boiler room and steam room.

The Black Diamond Coal and Coke Company, of Columbus, Ohio, will rebuild tipple and power house recently burned at Lathrop, Ohio.

The St. Louis & Illinois Coal Company, Edwardsville, Ill., is contemplating the installation of an electric plant for haulage and cutting.

Franchise has been granted to Clay Brothers, of San Angelo, Tex., to establish an ice factory and electric-light plant at Fort Stockton, Tex.

The Fresno-Hanford Interurban Electric Company, Fresno, Cal., will build a power plant near Fowler, Cal. About $100,000 will be expended.

The Illinois Traction System, Champaign, Ill., is said to be contemplating the erection of a power house in Atchison, Ill., to cost about $300,000.

T. F. Peck and associates have applied to the city council, Etowah, Tenn., for a franchise to install an electric-light and ice plant and waterworks.

Davis & Quick, 315 St. Marks avenue, Brooklyn, N. Y., are in the market for small steam engines about 10, 15 or 20 horsepower, horizontal or vertical.

The New York State School for the Blind, Batavia, N. Y., will build a refrigerating plant as per plans of Franklin B. Ware, State architect, Albany, N. Y.

The Brookville (Penn.) Water Company will enlarge and improve its system. New equipment will be purchased, including pumps, electrical machinery, etc.

The Eastern Michigan Power Company, Saginaw, Mich., will construct a dam and power plant on the Au Sable river, for which plans are being prepared.

Plans are being considered by the City Council, of Columbus, Ind., for remodeling the municipal electric-light plant and installing additional equipment.

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open bids January 17 for two sets of refrigerating machinery, Schedule No. 3227.

The Director of Public Works, Coshocton, Ohio, has been authorized to advertise for bids for an additional steam or electrically driven pump for the waterworks.

Plans are being considered, it is reported, by the Morgantown & Dunkard Valley Railroad Company for the erection of a new power house in Morgantown, W. Va.

Rollins & Westover, Beals building, Kansas City, Mo., are preparing plans for a municipal electric-light plant and waterworks system for the city of Plattsburg, Mo.

The Fayette Light Company is being formed at Lexington, Ky., with $500,000 capital to construct and operate an electric power plant. A. H. Peck will be general manager.

A water, sewer and lighting system will be installed at the Fort Lapwai Indian School, Lapwai, Idaho. John Charles, Denver, Colo., supervisor of construction.

The Gogebic and Iron Counties Railway and Light Company, Ashland, Wis., will erect a dam and power plant at Mellen, Wis. D. W. Mead, of Madison, is preparing plans.

The C. Schenkberg Company, Sioux City, Iowa, has had plans prepared for the construction of a new power house, near its new warehouse on Third and Douglas streets.

The plants of the Fredonia Heating Company, and power house of the Buffalo, Lake Erie & Western Traction Company, Fredonia, N. Y., were badly damaged by an explosion.

The Sanitary Ice Company, Clarksburg, W. Va., has been incorporated to manufacture ice. Capital, $75,000. Incorporators, M. E. Henderson, John Patton, Nathan Knight, etc.

Power-plant equipment, ventilating apparatus, etc., will be required in the Children's Hospital to be erected at Los Angeles, Cal. Hunt, Eager & Burns, Los Angeles, are architects.

The New England Sanitarium, Melrose, Mass., is in the market for a deep-well pump for a 6-inch well, 400 feet deep, and a pneumatic storage of at least 50000 gallons capacity.

The Water, Light and Bond Commission, of Cartersville, Ga., has been authorized by the City Council to install additional machinery in the municipal electric-light plant. About $6000 will be expended.

NEW CATALOGS

H. Y. B. Osgood, 614 West Seventy-ninth street, Chicago, Ill. Circular. Favorite boiler compound.

Ziermore Regulator Company, Johnsonburg, Penn. Catalog. Pressure regulators. Illustrated, 6x9 inches.

The Ball & Wood Company, Elizabethport, N. J. Catalog. Rateau-Smoot turbines and generators. Illustrated, 6x9 inches.

Buffalo Steam Pump Company, Buffalo, N. Y. Catalog 230. Single-stage centrifugal pumps. Illustrated, 96 pages, 6x9 inches.

Green Engineering Company, Chicago, Ill. Catalog No. 8. GECO pneumatic ash-handling systems. Illustrated, 16 pages, 7x10 inches.

Allis-Chalmers Company, Milwaukee, Wis. Bulletin No. 1501. Reliance belted Corliss engines. Illustrated, 16 pages, 8x10½ inches.

The Chas. A. Strelinger Company, Detroit, Mich. Catalog. Brush-balanced engine and direct-connected lighting set. Illustrated, 100 pages, 6x9 inches.

The Ohio Blower Company, Cleveland, Ohio. Catalog. Swartwout exhaust heads, steam and oil separators, ventilators, etc. Illustrated, 16 pages, 3½x6 inches.

General Electric Company, Schenectady, N. Y. Bulletin No. 4662A. Thomson watt-hour meters for switchboard service. Illustrated, 18 pages, 8x10½ inches.

Ingersoll-Rand Company, 11 Broadway, New York. Form No. 3002. Class A-1 straight-line steam driven single-stage air compressors. Illustrated, 20 pages, 6x9 inches.

J. Faessler Manufacturing Company, Moberly, Mo. Catalog No. 27. Roller flue expanders, sectional beading expanders, flue cutters, etc. Illustrated, 32 pages, 6x9 inches.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—Experienced steam fitter foreman for manufacturing plant; state age, reference and salary expected. Address "CX," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn street, Chicago.

WANTED—Chief engineer for power plant, about one hundred miles from New York City; power plant consists of Curtis turbines and generators; also have charge of motors throughout industrial works in which this power plant is located; in answering give age, experience and salary expected. Box 346, POWER.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

MECHANICAL ENGINEER, technical man, experienced in the development and design of modern manufacturing and power plants. Box 342, POWER.

CHIEF ENGINEER, all-around experience, erecting and operating steam, electric, refrigerating and waterworks plants, wishes position. Box 348, POWER.

SALES MANAGER steam specialty line, familiar conditions in United States, desires position with concern wishing to exploit its lines. Box 349, POWER.

SITUATION WANTED by a young man; three years' experience in steam engineering; good mechanic; strictly temperate; references. Wm. M. Johnson, Jr., Mooseys, Conn.

A-1 GAS ENGINE and gas producer designer wishes change; years of experience from smallest to largest size; no experimenting; is now open for a position. Box 350, POWER.

WANTED—Position as engineer; twenty-four years old; had seven years' experience; can take charge of small plant; have my own tools; can do any kind of repair work; Middle West preferred. Box 347, POWER.

POSITION WANTED by first class man as chief engineer and master machinist of light and power plant; engines indicated, valves properly set; all trouble with your steam plants rectified. Address "W. W.," 38 Burnett St., Newark, N. J.

POWER PLANT machinery salesman, with nine years' successful selling experience, desires position in East; is thoroughly familiar with pumping machinery, air compressors, feed water heaters, condensing apparatus, boilers, engines, etc., and complete power plant design; best references for character and ability. Address "F. C. G.," 649 Drexel Bldg., Philadelphia, Penn.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS secured. C. L. Parker, Solicitor of Patents, 4 McGill Bldg., Washington, D. C.

WANTED—Agents, engineers preferred, to sell boiler cleaning chemicals; liberal commissions paid. Continental Chemical Co., Forest Bldg., Philadelphia, Penn.

THE ANNUAL MEETING of the stockholders of the Hill Publishing Company, for the election of directors for the ensuing year and for the transaction of such other business as may properly come before the meeting, will be held at the offices of the company, in the Hallenbeck building, 497-505 Pearl street, Borough of Manhattan, New York City, N. Y., on Tuesday, January 31, 1911, at 12 o'clock noon.

Dated, New York City, December 9, 1910.
Robert McKean, Secretary.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—Small screw cutting lathe, chuck and tools; fine condition; bargain. South Bend Machine Co., South Bend, Ind., 424 Madison St.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

CONDENSER FOR SALE—Blake vertical twin air pump and jet condenser; size 14x38 x21; pistons metallic packed, brass fittings, perfect condition, used four years; we need larger condenser. The Stanley Works, New Britain, Conn.

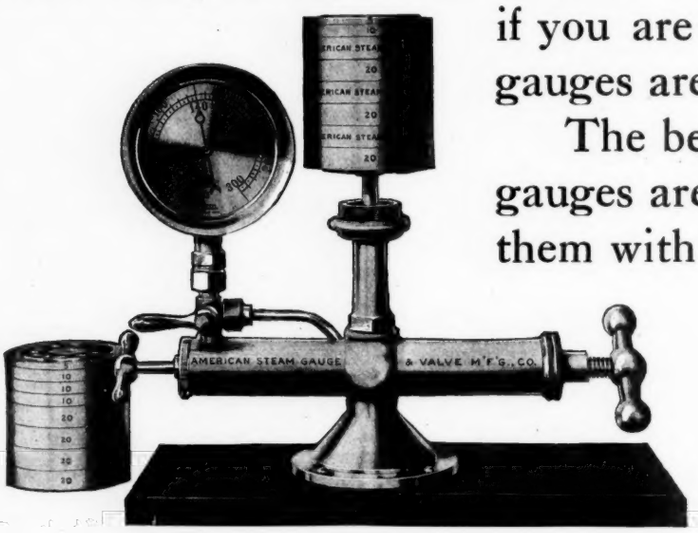
ALPHABETICAL INDEX TO ADVERTISERS

	PAGE
Acheson Graphite Co., International	86
Albany Lubricating Co.	93
Alberger Condenser Co.	105
Allan & Son, A.	111
Allis-Chalmers Co.	110
Alton, Laine & Co.	97
American Diesel Engine Co.	113
American District Steam Co.	111
American Eng. Co.	116
American Goetze-Gasket and Packing Co.	76
American Mfg. Co.	106
American Metal Hose Co.	104
American Radiator Co.	94
American Ship Windlass Co.	102
American Steam Gauge and Valve Mfg. Co.	64 and 65
Anderson Co., V. D.	95
Armstrong Mfg. Co.	90
Ashton Valve Co.	89
Austin Separator Co.	94
Babcock & Wilcox Co.	107
Baker Valve Co.	110
Ball & Wood Co.	116
Ball Engine Co.	114
Baragwanath & Son, Wm.	97
Barnes Co., W. F. & John	92
Beggs & Co., James	72
Bignall & Keeler Mfg. Co.	90
Blake & Knowles Steam Pump Works	96
Borden Co., The	90
Bristol Co.	4th cover
Brown Engine Co., C. H.	114
Brownell Co.	106
Bruce-Macbeth Engine Co.	106
Buckeye Engine Co.	117
Builders Iron Foundry	100
Burt Mfg. Co.	16
Cameron Steam Pump Works, A. S.	104
Cancos Mfg. Co.	99
Casey-Hedges Co.	107
Chaplin-Fulton Mfg. Co.	87
Chapman Valve Mfg. Co.	86
Chesterton Co., A. W.	82
Columbian Rope Co.	106
Cooper Co., C. & G.	114
Crosby Steam Gage & Valve Co.	88
Curtis & Curtis Co.	89
Dart Mfg. Co., E. M.	90
Dearborn Drug & Chemical Works	5
Deming Co.	104
Detroit Lubricator Co.	93
Diamond Rubber Co.	99
Dixon Crucible Co., Jos.	93
Du Bois Iron Works	112
Elliott Co.	7
Elyria Gas Power Co.	112
Engineer Co., The	86
Engineering Text Book Co.	84
Epping-Carpenter Co.	104
Eureka Packing Co.	99
Fitchburg Steam Engine Co.	114
Foos Gas Engine Co.	112
Foster Engineering Co.	86
Garlock Packing Co.	6
General Electric Co.	115
Goulds Mfg. Co.	104
Green Engineering Co.	103
Green Fuel Economizer Co.	102
Greene, Tweed & Co., 74 and 4th cover	
Griffith & Wedge Co.	117
Griscom-Spencer Co.	82
Hammel Oil Burner Co.	102
Harbison-Walker Refractories Co.	109
Harris Steam Engine Co., W. A.	114
Harrisburg Fdry. and Mach. Works	114
Harrison Safety Boiler Wks.	67
Hawkes Boiler Co.	107
Hawley Down Draft Furnace Co.	101
Heine Safety Boiler Co.	107
Heisler Co.	104
Hewes & Phillips Iron Wks.	114
Hoffman, Geo. W.	100
Homestead Valve Mfg. Co.	86
Hooven, Owens, Rentschler Co.	117
Hoppes Mfg. Co.	92
Hughson Steam Specialty Co.	87
Huyette Co., Inc., Paul B.	89
Industrial Instrument Co.	90
Ingersoll-Rand Co.	118
International Textbook Co.	71
Jamieson & Co., M. W.	86
Jefferson Union Co.	91
Jenkins Bros.	69
Johns-Manville Co., H. W.	81
Keeler Co., E.	107
Kellogg & Co., E. H.	92
Kellogg, M. W.	90
Kennicott Co.	97
Keystone Lubricating Co.	3
Kingsford Fdry. & Mach. Wks.	107
Lagonda Mfg. Co.	3d cover
Laidlaw-Dunn-Gordon Co.	111
Leddell-Bigelow Co.	110
Liberty Mfg. Co.	7
Lord Co., Geo. W.	77
Lunkenheimer Co.	4
McClave-Brooks Co.	12
McGraw-Hill Book Co.	80
McIntosh, Seymour & Co.	116
McLeod & Henry Co.	108
Magnolia Metal Co.	112
Manzel Bros. Co.	78
Mason Regulator Co.	89
Milne Water Tube Boiler Co.	82
Monarch Valve & Mfg. Co.	87
Morehead Mfg. Co.	95
Morrin Climax Boiler Co.	107
Morse Chain Co.	106
Murphy Iron Works	102
Nagle Corliss Engine Wks.	116
National India Rubber Co.	97
National Pipe Bending Co.	97
National Tube Co.	86
Neemes Bros.	100
Nelson Valve Co.	85
New Bedford Valve Mfg. Co.	86
New Process Raw Hide Co.	106
New York & New Jersey Lubricant Co.	81
New York Belting & Packing Co., Ltd.	10
New York Edsion Co.	76
Newhall Engr. Co., Geo. M.	83
Northern Equipment Co.	96
Ohio Blower Co.	79
Ohio Brass Co.	88
Oil Well Supply Co.	108
Open Coil Heater & Purifier Co.	95
Osgood Mfg. Co.	78
Parson Mfg. Co.	100
Patterson & Co., Frank L.	97
Peerless Rubber Mfg. Co.	8
Penberthy Injector Co., 1st cover	
Pennsylvania Flexible Metallic Tubing Co.	104
Perfection Grate Co.	100
Philadelphia Grease Mfg. Co.	93
Pierce Co., Wm. B.	2d cover
Pittsburgh Valve, Fdry. and Construction Co.	86
Power Specialty Co.	97
Precision Instrument Co.	96
Providence Engineering Wks.	117
Quaker City Rubber Co.	98
Reliance Gauge Column Co.	104
Richardson-Phenix Co.	84
Ridgway Dynamo and Engine Co.	116
Rochester Machine Tool Co.	114
Robb-Mumford Boiler Co.	107
Robertson & Sons, Jas. L.	73
Rollins Engine Co.	114
Ruggles Co., Walter G.	92
St. John, G. C.	74
Salamander Grate Bar Co.	100
Schaeffer & Budenberg Mfg. Co.	4th cover
Schieren Co., Chas. A.	106
Schuchardt & Schutte	96
Schutte & Koerting Co.	102
Simmons Co., John	84
Simplex Engineering Co.	87
Skinner Engine Co.	117
Smooth-On Mfg. Co.	9
Squires Co., C. E.	96
Starrett Co., L. S.	74
Steam Appliance Co., The	95
Steel Mill Packing Co.	99
Struthers-Wells Co.	112
Sturtevant Co., B. F.	111
Thermoid Rubber Co.	11
Treadwell Co., M. H.	100
Trill Indicator Co.	75
Trimont Mfg. Co.	92
Tripp Metallic Packing Co.	99
Toledo Pipe Threading Machine Co.	90
Turbo-Blower Co.	102
Turner-Fricke Mfg. Co.	112
Uehling Instrument Co.	104
Under-Feed Stoker Company of America	103
Underwood & Co., H. B.	112
Union Steam Pump Co.	104
Universal Lubricator Co.	13
Vilter Mfg. Co.	116
Vogt Machine Co., Henry	106
Von Kokeritz & Co., R. G.	84
Walton Co., F. S.	14 and 15
Washburn & Granger	100
Watson & McDaniel Co.	105
Watts-Campbell Co.	116
Westinghouse Elec. & Mfg. Co.	111
Wheeler Mfg. Co., C. H.	105
Whitlock Coil Pipe Co.	78
Wickes Boiler Co.	108
Willcox Engineering Co.	100
Williams & Co., J. H.	74
Williams Fdry. & Mach. Co.	106
Williams Tool Co.	97
Wilson, C. E.	105
Wing Mfg. Co., L. J.	78
Worthington, Henry R.	105
Wright Mfg. Co.	94
Yale & Towne Mfg. Co.	86
York Mfg. Co.	112
Ziermore Regulator Co.	87

A Device Which Enables You To Keep Your Gauges Accurate

How can you *know* what pressure is being carried on the boiler if you are not absolutely sure that the gauges are accurate?

The best way to be sure that your gauges are telling you "facts" is to test them with the



American Dead Weight Gauge Tester

This device enables you *to be sure* that the indicated pressure is the actual pressure being carried. No gauge, no matter how good, is proof against misuse or neglect.

Hence the necessity for testing the gauges every so often to make sure that the figures they show "don't lie."

For which purpose this American Dead Weight Gauge Tester is invaluable. It has all the advantages of the mercury column enclosed in a much smaller space.

It is the simplest and most reliable device made for the purpose; it is a necessary device to every engineer who wants to be sure that coal isn't being wasted in his plant.

Let us send you full details about this, as well as our other steam specialties.

American Steam Gauge & Valve Mfg. Company

Boston, Massachusetts.

New York, 26 Cortlandt Street. Chicago, 130-132 No. Jefferson Street. Atlanta, 525 Candler Bldg. Pittsburg, Columbia Bank Bldg. San Francisco, Monadnock Bldg. Montreal, 444 St. James St. Los Angeles, 213 So. Los Angeles St.

Keep Your Eyes on the Job Ahead

But don't forget that to win promotion you must first be thoroughly efficient in your present job.

You yourself, if you were an employer, wouldn't promote a man who wasn't "making good."

And your employer is just the same in this respect.

Put your best efforts into your work, show the boss that you are saving money for him, and promotion will come easily.

To do this, you should own an accurate indicator, an American-Thompson, and use it frequently.

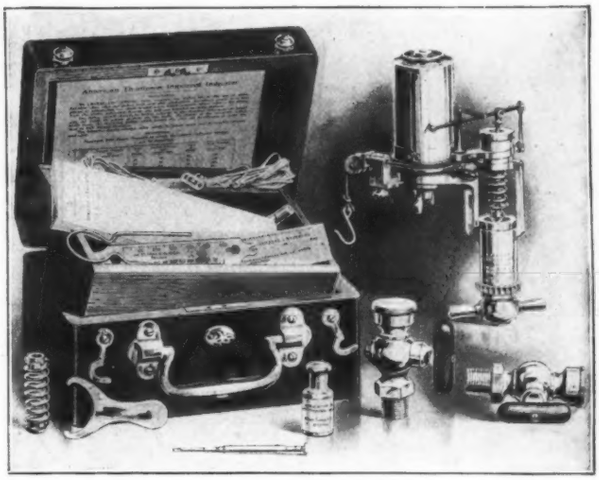
With the aid of this instrument you can know instead of guess what is happening inside the cylinder.

You can keep the valves properly adjusted, prevent leaks in the valves or piston, save coal, save wear and tear of the engine, reduce engine repairs.

You can, in other words, do your work as it should be done—at the least cost for fuel and repairs.

Then you can keep your eyes on the job ahead, knowing that you will be found "fit" when your opportunity comes.

But when buying an indicator be sure that you buy an indicator that is absolutely accurate, for misleading diagrams will only get you into trouble.



Buy an American-Thompson

Because it is the Best Indicator Made. Special materials are used to begin with. Experienced men make the parts and experienced men put them together.

The detent motion is an improved motion; it is patented and can be used only on the American-Thompson.

It is positive, gentle and instantaneous.

It engages and releases the drum on the highest speeds as rapidly as the hand can move and is absolutely free from jars and shocks.

And each instrument before shipment is put to a final test, more severe than any you will ever give it.

Consequently when you buy an American-Thompson you buy a lasting instrument, one that you can use year after year knowing that the diagrams you take with it are right.

$5.00 Secures It—Mail The Coupon

Five dollars down, then five dollars monthly. Send the first payment today and we'll start an American-Thompson right off on its way to you. We extend to you the privilege of examining the outfit for a period of five days and we have never had one single outfit returned to us. This right is allowed to every purchaser.

If you want more information send the coupon for our Indicator proposition No. 92.

But don't wait—whatever you do—do it to-day.

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

New York Chicago Atlanta
Pittsburg San Francisco Los Angeles

The Outfit

The Indicator, inclosed or exposed spring type as preferred, two single cocks or one 3-way cock (as preferred), one scale, all necessary wrenches, screw-driver, bottle of porpoise oil, etc., all inclosed in a neat mahogany box, together with 200-page book—Indicator Instructions.

The Terms

Suitable references and an initial payment of $5.00 secure the Indicator Outfit at once. $5.00 a month pays the balance. The total cost is $55. (Detent motion extra.) Remember that, as stated, you may have the outfit for examination without risk whatever.

American Steam Gauge & Valve Mfg. Co.
Boston, Mass.

Send me full details of your Indicator Offer No. 92.

Name . . . . . .

Address . . . . . .

City and State . . . . . .

CLASSIFIED INDEX *to* ARTICLES ADVERTISED

Air Compressors

Allis-Chalmers Co.....110
Ingersoll-Rand Co.....118
Union Steam Pump Co.....104

Alarms, Low Water

Lunkenheimer Co..... 4
Reliance Gauge Column Co...104
Wright Mfg. Co..... 94

Alternators

Allis-Chalmers Co.....110
General Electric Co.....115

Asbestos Goods and Materials

Johns-Manville Co., H. W.... 81

Belt Dressing

Garlock Packing Co..... 6
Houghton & Co., E. F..... 87
Keystone Lubricating Co.... 3
Schieren Co., Chas. A.....106
Walton Co., F. S.....14 and 15

Belt Fasteners

Bristol Co.....4th cover

Belt Lace

Schieren Co., Chas. A.....106

Belting

Diamond Rubber Co..... 99
Garlock Packing Co..... 6
New York Belting & Pack. Co. 10
Peerless Rubber Mfg. Co..... 8
Schieren Co., Chas. A.....106

Belting, Chain

Morse Chain Co.....106

Blocks, Chain

Yale & Towne Mfg. Co..... 86

Blowers, Fan

Green Fuel Economizer Co...102
Ohio Blower Co..... 79
Sturtevant Co., B. F.....111
Turbo-Blower Co.....102
Wing Mfg. Co., L. J..... 78

Blowers, Steam Jet

McClave-Brooks Co..... 12
Parson Mfg. Co..... 79

Boiler Fronts

Casey-Hedges Co.....107
Treadwell Co., M. H.....100

Boiler Setting

Harbison-Walker Refractories Co.....109
Hawley Down Draft Furnace Co.....101
McLeod & Henry Co.....108

Boilers

Babcock & Wilcox Co.....107
Beggs & Co., James..... 72
Casey-Hedges Co.....107
Griffith & Wedge Co.....117
Harrisburg Foundry & Mach. Works.....114
Harrison Safety Boiler Wks.. 67
Heine Safety Boiler Co.....107
Hewes & Phillips Iron Wks...114
Keeler Co., E.....107
Kingsford Fdry. & Mach. Co..107
Milne Water Tube Boiler Co.. 82
Morrin Climax Boiler Co.....107
New Bedford Valve Mfg. Co.. 86
Oil Well & Supply Co..... 108
Robb-Mumford Boiler Co.....107
Struthers-Wells Co.....112
Vogt Machine Co., Henry....106
Wickes Boiler Co.....108
York Mfg. Co.....112

Books

International Text Book Co.. 71
Engineering Text Book Co.... 84
McGraw-Hill Book Co..... 80

Brick, Fire

Harbison-Walker Refractories Co.....109
McLeod & Henry Co.....108

Calorimeters

Schaeffer & Budenberg Mfg. Co.....4th cover

Castings, Brass and Iron

Bruce-Macbeth Eng. Co.....106
Hooven, Owens, Rentschler Co.117
Lunkenheimer Co., The..... 4
McClave-Brooks Co..... 12
Neemes Bros.....100
Ohio Brass Co..... 88
Salamander Grate Bar Co....100
Treadwell Co., M. H.....100

Castings, Steel

Hooven, Owens, Rentschler Co.117
Treadwell Co., M. H.....100

Cement, Iron

Johns-Manville Co., H. W.... 81
Smooth-On Mfg. Co..... 9

Cement, Rubber

Peerless Rubber Mfg. Co..... 8

Chain Drives

Morse Chain Co.....106

Chimneys, Brick

Kellogg Co., M. W..... 10

Chimneys, Steel

Keeler Co., E.....107
Morrin Climax Boiler Co.....107
Treadwell Co., M. H.....100

Clocks

American Steam Gauge and Valve Mfg. Co.....64 and 65
Industrial Instrument Co.... 90

Clutches, Friction

Allis-Chalmers Co..... 110
Williams Fdry. & Mach. Co..106

Cocks, Blow-off

Liberty Mfg. Co..... 7

Cocks, Gage

American Steam Gauge and Valve Mfg. Co.....64 and 65
Huyette Co., Paul B..... 89
Jenkins Bros..... 69
Lunkenheimer Co., The..... 4
Ohio Blower Co..... 79
Reliance Gauge Column Co... 84
Wright Mfg. Co..... 94

Cocks, Steam

Dart Mfg. Co., E. M..... 90
Lunkenheimer Co..... 4
Schutte & Koerting Co.....102

Combustion Recorders

Precision Instrument Co..... 96
Uehling Instrument Co.....104

Compound, Boiler

Dearborn Drug and Chemical Works..... 5
Johns-Manville Co., H. W.... 81
Keystone Lubricating Co.... 3
Liberty Mfg. Co..... 7
Lord Co., Geo. W..... 77
Osgood Mfg. Co..... 78

Compound, Commutator

Acheson Graphite Co., International..... 86
Dixon Crucible Co., Jos..... 93
Osgood Mfg. Co..... 78

Condensers

Alberger Condenser Co.....105
Allis-Chalmers Co.....110
Anderson Co., V. D..... 95
Baragwanath & Son, Wm.... 97
Cameron Steam Pump Works, A. S.....104
Epping-Carpenter Co.....104
Kellogg Co., M. W..... 90
Schutte & Koerting Co.....102
Union Steam Pump Co.....104
Wheeler Mfg. Co., C. H.....105

Controllers, Electric

General Electric Co.....115
Westinghouse Elec. & Mfg. Co.111

Controllers, Feed Water

Mason Regulator Co..... 89
Northern Equipment Co..... 96
Squires Co., C. E..... 96
Ziermore Regulator Co..... 87

Cooling Plants

Schutte & Koerting Co.....102

Cooling Towers

Wheeler Mfg. Co., C. H.....105

Cordage

American Mfg. Co.....106
Columbian Rope Co.....106

Correspondence Schools

International Textbook Co... 71

Couplings, Flexible Shaft

Bruce-Macbeth Engine Co.....106
Hooven, Owens, Rentschler Co.117

Couplings, Pipe

Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Coverings, Pipe and Boiler

Houghton & Co., E. F..... 87
Johns-Manville Co., H. W.... 81

Cranes

Yale & Towne Mfg. Co..... 86

Die Stocks

Armstrong Mfg. Co..... 90
Bignall & Keeler Mfg. Co.... 90
Curtis & Curtis Co..... 89
Toledo Pipe Threading Mach. Co..... 90

Draft, Mechanical

Engineer Co., The..... 86
Green Fuel Economizer Co...102
Parson Mfg. Co.....100
Schutte & Koerting Co.....102
Turbo-Blower Co.....102
Wing Mfg. Co., L. J..... 78

Drills, Upright

Barnes Co., W. F. & John.... 92

Dust Collectors

Ohio Blower Co..... 79
Sturtevant Co., B. F.....111

Dynamos

Allis-Chalmers Co.....110
American Engine Co.....116
Bruce-Macbeth Eng. Co.....106
General Electric Co.....115
Ridgway Dynamo and Engine Co.....116
Sturtevant Co., B. F.....111
Westinghouse Elec. & Mfg. Co.111

Ejectors

Beggs & Co., James..... 72
Lunkenheimer Co..... 4
Penberthy Injector Co..1st cover
Schutte & Koerting Co.....102

Electric Current

New York Edison Co..... 76

Engine Stops

Schutte & Koerting Co.....102

Engines, Combustion

Allis-Chalmers Co.....110
American Diesel Engine Co..113
Bruce-Macbeth Eng. Co.....106
Buckeye Engine Co.....117
Du Bois Iron Works.....112
Elyria Gas Power Co.....112
Foos Gas Engine Co.....112
Struthers-Wells Co.....112
Turner-Fricke Mfg. Co.....112
Westinghouse Elec. & Mfg. Co..111

Engines, Steam

Allis-Chalmers Co.....110
American Eng. Co.....116
Ball & Wood Co.....116
Ball Engine Co.....114
Beggs & Co., James..... 72
Brown Engine Co., C. H.....114
Brownell Co.....106
Buckeye Engine Co.....117
Brown Engine Co., C. H.....114
Cooper Co., C. & G.....114
Du Bois Iron Works.....112
Green Fuel Economizer Co...102
Griffith & Wedge Co.....117
Harris Steam Eng. Co., Wm. A.114
Harrisburg Fdry & Mach. Wks.114

Engines, Steam—*Continued.*

Hewes & Phillips Iron Wks..114
Hooven, Owens, Rentschler Co.117
McIntosh, Seymour & Co....116
Nagle Corliss Engine Works..116
Providence Engineering Wks.117
Ridgway Dynamo & Engine Co.116
Rollins Engine Co.....114
Rochester Machine Tool Co...114
Skinner Engine Co.....117
Sturtevant Co., B. F.....111
Watts, Campbell Co.....116
York Mfg. Co.....112

Exhaust Heads

Burt Mfg. Co..... 16
Hoppes Mfg. Co..... 92
Ohio Blower Co..... 79
Patterson & Co., Frank L.... 97
Robertson & Sons, Jas. L.... 73
Ruggles Co., Walter G..... 92
Sturtevant Co., B. F.....111
Whitlock Coil Pipe Co..... 78
Wright Mfg. Co..... 94

Expansion Joints

Alberger Condenser Co.....105

Fans, Exhaust and Ventilating

Anderson Co., V. D..... 95
General Electric Co.....115
Green Fuel Economizer Co...102
Power Specialty Co..... 97
Sturtevant Co., B. F.....111
Turbo-Blower Co.....102
Westinghouse Elec. & Mfg. Co.111
Wing Mfg. Co., L. J..... 78

Feeders, Furnace

Kennicott Co., The..... 97
Ohio Blower Co..... 79

Filters, Feed Water

Beggs & Co., James..... 72

Filters, Oil

Burt Mfg. Co..... 16
Houghton & Co., E. F..... 87
industrial Instrument Co.... 90
Liberty Mfg. Co..... 7
Richardson-Phenix Co..... 84
Robertson & Sons, Jas. L.... 73
Ruggles Co., Walter G..... 92
Wright Mfg. Co..... 94

Firebox Blocks

Harbison-Walker Refractories Co.....109
McLeod & Henry Co.....108

Fittings, Ammonia

American Steam Gauge and Valve Mfg. Co.....64 and 65
York Mfg. Co.....112

Fittings, Steel

Nelson Valve Co..... 85

Flanges

Ball & Wood Co.....116
Dart Mfg. Co., E. M..... 90
Jefferson Union Co..... 91

Floats

Anderson Co., V. D..... 95
Schutte & Koerting Co.....102

Flue Gas Analysis Instruments

Pierce Co., Wm. B.....2d cover

Fuel Economizers

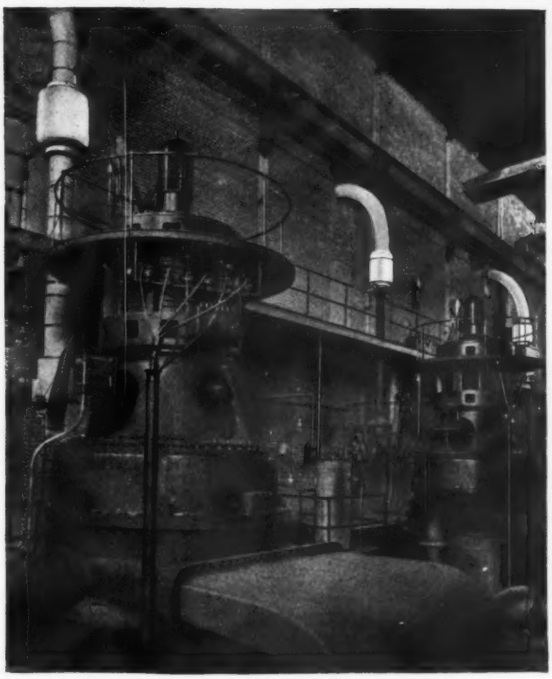
Green Fuel Economizer Co....102
Parsons Mfg. Co.....100
Sturtevant Co., B. F.....111

Furnace Door Arch

Harbison-Walker Refractories Co.....109
McLeod & Henry Co.....108

Furnaces, Smokeless

Hawley Down Draft Furnace Co.....101
McClave-Brooks Co..... 12
Murphy Iron Works.....102



When Boilers Prime Or Foam

Prof. C. H. Peabody says that priming is the moral condition of operation of boilers with proper steam space and free water surface, and further that many boilers, because of the character of the feed water or peculiarities of construction, foam violently. *The remedy suggested by him is the installation of a good steam separator. The best steam separator for the purpose is the*

COCHRANE RECEIVER SEPARATOR

which is so designed that it removes from the steam the constant small percentage of water, in addition to protecting the engine or turbine from the disastrous effects of large slugs of water.

It is highly important that this water be removed from the steam, since it washes the lubricating oil from the valves, pistons and cylinder surfaces, making lubrication difficult, or erodes the blades and decreases the steam economy of the turbine, for it is a well known fact that each pound of water in the steam entering a turbine entails the consumption of an extra pound of steam to produce a horsepower hour.

The high efficiency of the Cochrane Separator in removing the suspended particles of moisture from the steam is due to the fact that once the water particles have been projected against the vertical ribbed baffle, they cannot be brushed off, since the ribs prevent, and they are drained at once into the well, where they are entirely removed from the action of the steam current.

By providing a large supply of steam close to the engine throttle, the Cochrane Receiver Separator renders the flow through the steam piping more uniform, so that a higher average pressure is maintained in the steam chest, or smaller piping can be used while maintaining the same pressure, thereby economizing on the cost of piping, and avoiding part of the loss due to radiation from the steam line.

If you are troubled with water in your steam pipes, engines or turbines, or if you wish to purify exhaust steam of oil so that it can safely be used for boiler feeding after condensation in a heating or drying system, or so that it will be entirely suitable for operating exhaust steam turbines or absorption ice machines, send us particulars, and we shall be pleased to give you our best recommendation. During twenty years of installing separators we have learned important facts about the best ways of arranging piping, etc., which may be of value to you.

Ask for a copy of our *"Separator Talks."* If you are interested in heating water for boiler feeding or other purposes, or in softening water so that it will not form scale in the boilers, possibly you would like to have our booklets *"The Profitable Utilization of Exhaust Steam,"* or *"Hot Soft Water for Boiler Feeding."*

Harrison Safety Boiler Works

17th & Clearfield Streets **Philadelphia, Penna.**

Gage Boards

American Steam Gauge and Valve Mfg. Co.....64 and 65

Gage Glasses

American Steam Gauge and Valve Mfg. Co.....64 and 65
Chesterton Co., A. W.....105
Garlock Packing Co..... 6
Peerless Rubber Mfg. Co..... 8
Von Kokeritz & Co., R. G.... 78

Gage Testing Outfit

American Steam Gauge and Valve Mfg. Co.....64 and 65

Gages, Draft

American Steam Gauge and Valve Mfg. Co.....64 and 65
Bristol Co.....4th cover
Schaeffer & Budenberg Mfg. Co. .....4th cover

Gages, Pressure

American Steam Gauge and Valve Mfg. Co.....64 and 65
Ashton Valve Co..... 89
Crosby Steam Gage & Valve Co. 88
Industrial Instrument Co..... 90
Schaeffer & Budenberg Mfg. Co. .....4th cover

Gages, Recording

American Steam Gauge and Valve Mfg. Co.....64 and 65
Ashton Valve Co..... 89
Bristol Co.....4th cover
Industrial Instrument Co.... 90
Schaeffer & Budenberg Mfg. Co. .....4th cover

Gages, Vacuum

American Steam Gauge and Valve Mfg. Co.....64 and 65
Industrial Instrument Co.... 90
Schaeffer & Budenberg Mfg. Co. .....4th cover
Schutte & Koerting Co.....102

Gages, Water

American Steam Gauge and Valve Mfg. Co.....64 and 65
Greene, Tweed & Co., 74 and 4th cover
Huyette Co., Paul B..... 89
Jenkins Bros..... 69
Lunkenheimer Co..... 4
Ohio Blower Co..... 79
Reliance Gauge Column Co...104
Wright Mfg. Co..... 94

Gas Exhausters

Ohio Blower Co..... 79

Gas Producers

Du Bois Iron Works.....112
Foos Gas Engine Co.....112

Gaskets

American Goetze-Gasket and Packing Co..... 76
Cancos Mfg. Co..... 99
Diamond Rubber Co..... 99
Eureka Packing Co..... 99
Garlock Packing Co..... 6
Greene, Tweed & Co., 74 and 4th cover
Houghton & Co., E. F..... 87
Jenkins Bros..... 69
Johns-Manville Co., H. W.... 81
Keeler Co., E.....107
National India Rubber Co.... 97
New York Belting & Packing Co. 10
Peerless Rubber Mfg. Co..... 8

Gears

New Process Raw Hide Co...106

Generating Sets

American Engine Co.....116
Foos Gas Engine Co.....112
General Electric Co.....115
Harris Steam Engine Co., Wm.114
Harrisburg Foundry and Machine Works.....114
Ridgway Dynamo & Engine Co.116
Sturtevant Co., B. F.....111
Westinghouse Elec. & Mfg. Co.111

Governors, Pump

Foster Engineering Co..... 86
Mason Regulator Co..... 89
Northern Equipment Co..... 96
Squires Co., C. F..... 96
Watson & McDaniel Co.....105
Ziermore Regulator Co..... 87

Governors, Pump Speed

Mason Regulator Co..... 89
Ziermore Regulator Co..... 87

Graphite

Acheson Graphite Co., International 86
Dixon Crucible Co., Jos..... 93
Garlock Packing Co..... 6

Grates

Casey-Hedges Co.....107
Green Engineering Co.....103
McClave-Brooks Co..... 12
Neemes Bros.....100
Perfection Grate Co.....100
Salamander Grate Bar Co....100
Treadwell Co., M. H.....100
Washburn & Granger.....100

Grease

Acheson Graphite Co., International 86
Albany Lubricating Co..... 93
Dearborn Drug & Chemical Works 5
Dixon Crucible Co., Jos..... 93
Kellogg & Co., E. H..... 92
Keystone Lubricating Co..... 3
Philadelphia Grease Co..... 93
Walton Co., F. S.....14 and 15

Grease Extractors

Beggs & Co., James..... 72
Griscom-Spencer Co..... 82

Heaters and Purifiers, Feed Water

Alberger Condenser Co.....105
Baragwanath & Son, Wm..... 97
Casey-Hedges Co.....107
Green Fuel Economizer Co...102
Griscom-Spencer Co..... 82
Harrison Safety Boiler Wks.. 67
Hoppes Mfg. Co..... 92
National Pipe Bending Co.... 97
Open Coil Heater & Purifier Co. 95
Patterson & Co., Frank L.... 97
Robertson & Sons, Jas. L.... 73
Wheeler Mfg. Co., C. H.....105
Whitlock Coil Pipe Co..... 78
Wickes Boiler Co.....108
Williams Tool Co..... 97

Heating and Ventilating Systems

Green Fuel Economizer Co....102
Ohio Blower Co..... 79
Schutte & Koerting Co.....102
Wing Mfg. Co., L. J..... 78

Heating, Central Station

American District Steam Co..111

Hoists, Electric

Allis-Chalmers Co.....110
Yale & Towne Mfg. Co..... 86

Hoists, Hand

Yale & Towne Mfg. Co..... 86

Hose, Metal

American Metal Hose Co.....104
Pennsylvania Flexible Metallic Tubing Co.....104

Hose, Rubber

Diamond Rubber Co..... 99
Garlock Packing Co..... 6
Lagonda Mfg. Co.....3d cover
New York Belting & Packing Co. 10
Peerless Rubber Mfg. Co..... 8
Pennsylvania Flexible Metallic Tubing Co.....104

Ice and Refrigerating Machinery

Vilter Mfg. Co.....116
Vogt Machine Co., Henry....106
York Mfg. Co.....112

Indicators, Ammonia

American Steam Gauge and Valve Mfg. Co.....64 and 65

Indicators, Gas Engine

American Steam Gauge and Valve Mfg. Co.....64 and 65
Schaeffer & Budenberg Mfg. Co. .....4th cover
Trill Indicator Co..... 75

Indicators, Speed

Schaeffer & Budenberg Mfg. Co. .....4th cover
Starrett Co., L. S..... 74

Indicators, Steam Engine

American Steam Gauge and Valve Mfg. Co.....64, 65
Crosby Steam Gage & Valve Co. 88
Robertson & Sons, Jas. L.... 73
Schaeffer & Budenberg Mfg. Co. .....4th cover
Trill Indicator Co..... 75

Injectors

Jenkins Bros..... 69
Lunkenheimer Co..... 4
Penberthy Injector Co..1st cover
Robertson & Sons, Jas. L.... 73
Schutte & Koerting Co.....1 2

Lamps, Acetylene

Simmons Co., John..... 84

Lamps, Electric

General Electric Co.....115
Johns-Manville Co., H. W.... 81
Westinghouse Elec. & Mfg. Co.111

Lathes, Foot Power

Barnes Co., W. F. & John.... 75

Lubricators, Cylinder

Detroit Lubricator Co..... 93
Greene, Tweed & Co., 74 and 4th cover
Griscom-Spencer Co..... 82
Lunkenheimer Co..... 4
Manzel Bros. Co..... 84
Robertson & Sons, Jas. L.... 73
Richardson-Phenix Co..... 84
Universal Lubricator Co..... 11

Lubricators, Force Feed

Lunkenheimer Co..... 4
Richardson-Phenix Co..... 84

Mats and Matting

Diamond Rubber Co..... 99
New York Belting & Packing Co 10
Peerless Rubber Mfg. Co.... 8

Metal, Bearing

Allan & Son, A.....111
Leddell-Bigelow Co.....110
Magnolia Metal Co.....112

Meters, Steam

General Electric Co.....115

Meters, Water

Builders Iron Foundry.....100

Micrometers

Starrett Co., L. S..... 74

Milling Machines, Portable

Underwood & Co., H. B.....112

Motors, Electric

Allis-Chalmers Co.....110
American Engine Co.....116
General Electric Co.....115
Ridgway Dynamo & Engine Co 116
Sturtevant Co., B. F.....111
Westinghouse Elec. & Mfg. Co.111

Motors, Water

Lagonda Mfg. Co.....3d cover

Oil and Grease Cups

Albany Lubricating Co..... 93
Detroit Lubricating Co..... 93
Keystone Lubricating Co.... 3
Liberty Mfg. Co..... 7
Lunkenheimer Co..... 4
New York & New Jersey Lubricant Co..... 81
Richardson-Phenix Co..... 84
Schaeffer & Budenberg Mfg. Co. .....4th cover
Universal Lubricating Co.... 11

Oil Burners

Hammel Oil Burner Co.....102
Lunkenheimer Co..... 4
Parson Mfg. Co.....100

Oil Reservoirs

Burt Mfg. Co..... 16
Richardson-Phenix Co..... 84

Oil Systems

Burt Mfg. Co..... 16
Cook's Sons, Adam..... 93
Detroit Lubricator Co..... 93
Industrial Instrument Co.... 90
Lunkenheimer Co..... 4
Richardson-Phenix Co..... 84

Oils

Albany Lubricating Co..... 93
Dearborn Drug & Chemical Works 5
Kellogg & Co., E. H..... 92
New York & New Jersey Lubricant Co..... 81
Walton Co., F. S.....14 and 15

Packing, Flange

American Goetze-Gasket and Packing Co..... 76
Cancos Mfg. Co..... 99
Chesterton Co., A. W.....105
Diamond Rubber Co..... 99
Eureka Packing Co..... 99
Garlock Packing Co..... 6
Greene, Tweed & Co., 74 and 4th cover
Jenkins Bros..... 69
Johns-Manville Co., H. W.... 81
National India Rubber Co... 97
New York Belting & Packing Co. 10
Peerless Rubber Mfg. Co.... 8
Robertson & Sons, Jas. L.... 73
Smooth-On Mfg. Co..... 9
Thermoid Rubber Co..... 11
Von Kokeritz & Co., R. G.... 84

Packing, Hydraulic

Johns-Manville Co., H. W.... 81
Von Kokeritz & Co., R. G.... 84

Packing, Pump Valve

Cancos Mfg. Co..... 99
Diamond Rubber Co..... 99
Von Kokeritz & Co., R. G.... 84

Packing, Rod

American Goetze-Gasket and Packing Co..... 76
Cancos Mfg. Co..... 99
Chesterton Co., A. W.....105
Diamond Rubber Co..... 99
Eureka Packing Co..... 99
Garlock Packing Co..... 6
Greene, Tweed & Co., 74 and 4th cover
Johns-Manville Co., H. W.... 81
National India Rubber Co.... 97
New York Belting and Packing Co..... 10
Peerless Rubber Mfg. Co..... 8
Power Specialty Co..... 97
Robertson & Sons, Jas. L.... 73
Steel Mill Packing Co..... 99
Thermoid Rubber Co..... 11
Tripp Metallic Packing Co... 99
Von Kokeritz & Co., R. G.... 84

Pipe

Ball & Wood Co.....116

Pipe Bending

Ball & Wood Co.....116
Kellogg Co., M. W..... 90
National Pipe Bending Co.... 97
Whitlock Coil Pipe Co..... 78

Pipe Clamp

Simplex Engineering Co..... 87

Pipe Coils

National Pipe Bending Co.... 97
Whitlock Coil Pipe Co..... 78

Pipe Cutting and Threading Machines

Armstrong Mfg. Co..... 90
Bignall & Keeler Mfg. Co.... 90
Curtis & Curtis Co..... 89
Toledo Pipe Threading Machine Co..... 90
Treadwell Co., M. H.....100
Trimont Mfg. Co..... 92

Piping, Blow

Ohio Blower Co..... 79

Piping, High Pressure

Kellogg Co., M. W..... 90

Planimeters

American Steam Gauge and Valve Mfg. Co.....64 and 65
Robertson & Sons, Jas. L.... 73

Polish, Metal

Hoffman, Geo. W.....100
Johns-Manville Co., H. W.... 81

Publishers

International Textbook Co.... 71
McGraw-Hill Book Co..... 80

Pumps, Air

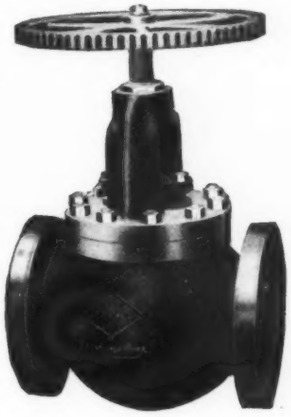
Cameron Steam Pump Wks., A. S..... 104
Du Bois Iron Works.....112
Goulds Mfg. Co.....104
Wheeler Mfg. Co., C. H.....105
Wilson, C. E.....105

JENKINS·BROS·VALVES·

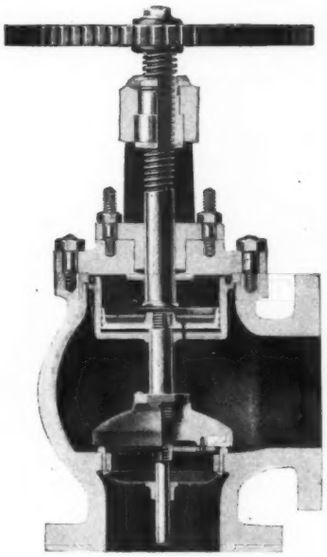
TRADE JENKINS MARK

Jenkins Bros.

Automatic Equalizing Stop And Check Valves Extra Heavy Pattern



SUPPOSE a tube should burst in a boiler, or some other internal rupture take place that would suddenly reduce the pressure in that particular boiler—



In a case like this the Jenkins Bros. Automatic Equalizing Stop and Check Valve would immediately shut off the flow of steam from the header into the boiler.

But they are more than emergency valves—they equalize the pressure between the different boilers in a battery so that no one boiler will be working at a lower pressure than another.

They can only be opened by pressure in the boiler to which they are attached so that no steam can accidentally be turned into any boiler while it is being cleaned. They are thoroughly modern, have full opening, and are made strong and rigid to withstand the strains due to expansion and contraction of the piping.

They are cushioned to prevent hammering or chattering; are tested to 800 lbs. hydraulic pressure and guaranreed for working steam pressures up to 250 lbs.

Furnished in extra Heavy Pattern in all sizes from 4″ to 12″ either screwed or flanged.

Write for special bulletin giving full details.

Jenkins Bros.

71 John St., New York — 35 High St., Boston — 133 N. 7th St., Philadelphia
226-228 Lake St., Chicago

Pumps, Centrifugal
Allberger Condenser Co.....105
Allis-Chalmers Co.....110
Wilson, C. E.....105

Pumps, Deep Well
Cameron Steam Pump Wks., A. S.....104
Wilson, C. E.....105

Pumps, Electric
Du Bois Iron Works.....112
Goulds Mfg. Co.....104
Westinghouse Elec. & Mfg. Co. 111
Wilson, C. E.....105

Pumps, Oil
Burt Mfg. Co..... 16
Cameron Steam Pump Wks., A. S.....104
Du Bois Iron Works.....112
Goulds Mfg. Co.....104
Lunkenheimer Co..... 4
Manzel Bros. Co..... 84
Wilson, C. E.....105

Pumps, Oil Force-feed
Detroit Lubricator Co..... 93
Lunkenheimer Co..... 4

Pumps, Power
Du Bois Iron Works.....112
Goulds Mfg. Co.....104
Patterson & Co., Frank L.... 97
Union Steam Pump Co.....104
Whitlock Coil Pipe Co..... 78
Wilson, C. E.....105

Pumps, Steam
Allis-Chalmers Co.....110
Cameron Steam Pump Wks., A. S.....104
Du Bois Iron Works.....112
Epping-Carpenter Co.....104
Goulds Mfg. Co.....104
Heisler Co.....104
Jamieson & Co., W W..... 86
Union Steam Pump Co.....104
Wheeler Mfg. Co., C. H.....105
Wilson, C. E.....105

Pumps, Vacuum
Allberger Condenser Co.....105
Cameron Steam Pump Wks., A. S.....104
Goulds Mfg. Co.....104
Union Steam Pump Co.....104
Wheeler Mfg. Co., C. H.....105
Wilson, C. E.....105

Pyrometers
American Steam Gauge and Valve Mfg. Co.....64 and 65
Schaeffer & Budenberg Mfg. Co. .....4th cover
Uehling Instrument Co.....104

Rams, Steam
Penberthy Injector Co..1st cover

Reducing Wheels
American Steam Gauge and Valve Mfg. Co.....64 and 65
Robertson & Sons, Jas. L.... 73
Trill Indicator Co..... 75

Regulators, Damper
Lagonda Mfg. Co.....3d cover
Mason Regulator Co..... 89
Robertson & Sons, Jas. L.... 73
Turbo-Blower Co.....102

Regulators, Feed Water
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7
Northern Equipment Co..... 96
Squires Co., C. E..... 96
Ziermore Regulator Co..... 87

Regulators, Pressure
Foster Engineering Co..... 86
Hughson Steam Specialty Co. 87
Lagonda Mfg. Co.....3d cover
Mason Regulator Co..... 89
Northern Equipment Co..... 96
Squires Co., C. E..... 96
Steam Appliance Co..... 95
Ziermore Regulator Co..... 87

Regulators, Pump
Hughson Steam Specialty Co. 87
Mason Regulator Co..... 89
Squires Co., C. E..... 96
Ziermore Regulator Co..... 87

Repairs, Engine
Underwood & Co., H. B.....112

Revolution Counters
American Steam Gauge and Valve Mfg. Co.....64 and 65
Schaeffer & Budenberg Mfg. Co. .....4th cover

Rope, Transmission
American Mfg. Co.....106
Columbian Rope Co.....106

Separators, Ammonia
Harrison Safety Boiler Wks.. 67

Separators, Oil
American Radiator Co..... 94
Austin Separator Co..... 94
Baragwanath & Son, Wm..... 97
Harrison Safety Boiler Wks.. 67
Hoppes Mfg. Co..... 92
Liberty Mfg. Co..... 7
Ohio Blower Co..... 79
Robertson & Sons, Jas. L.... 73
Ruggles Co., Walter G..... 92
Steam Appliance Co..... 95
Wright Mfg. Co..... 94

Separators, Steam
American Radiator Co..... 94
Austin Separator Co..... 94
Baragwanath & Son, Wm..... 97
Griscom-Spencer Co..... 82
Harrison Safety Boiler Wks.. 67
Hoppes Mfg. Co..... 92
Liberty Mfg. Co..... 7
Ohio Blower Co..... 79
Patterson & Co., Frank L.... 97
Robertson & Sons, Jas. L.... 73
Ruggles Co., Walter G..... 92
Steam Appliance Co..... 95
Whitlock Coil Pipe Co..... 78
Wright Mfg. Co..... 94

Skylights
Burt Mfg. Co..... 16

Steam Turbines
Allis-Chalmers Co.....110

Stokers, Mechanical
Babcock & Wilcox Co.....107
McClave-Brooks Co..... 12
Murphy Iron Works.....102
Parson Mfg. Co.....100
Under-Feed Stoker Company of America.....103

Stokers, Underfeed
American Ship Windlass Co. 102
Under-Feed Stoker Company of America.....103

Strainers, Pump Suction
Liberty Mfg. Co..... 7

Superheaters
Babcock & Wilcox Co.....107
Power Specialty Co..... 97
Providence Engineering Wks. 117

Switchboards
General Electric Co.....115
Westinghouse Elec. & Mfg. Co. 111

Tachometers
Industrial Instrument Co.... 90
Schaeffer & Budenberg Mfg. Co. .....4th cover
Schuchardt & Schutte..... 96

Tanks
Griscom-Spencer Co..... 82

Taps and Dies
Armstrong Mfg. Co..... 90
Bignall & Keeler Mfg. Co.... 90
Curtis & Curtis Co..... 89
Toledo Pipe Threading Machine Co..... 90

Thermometers
Bristol Co.....4th cover
Industrial Instrument Co.... 90
Schaeffer & Budenberg Mfg. Co. .....4th cover

Transformers and Converters
General Electric Co.....115
Westinghouse Elec. & Mfg. Co. 111

Transmission, Power
American Mfg. Co.....106
Columbian Rope Co.....106
Jeffrey Mfg. Co..... 97
Morse Chain Co.....106

Traps, Steam
American Radiator Co..... 94
Anderson Co., V. D..... 95
Jenkins Bros..... 69
Morehead Mfg. Co..... 95
Newhall Eng. Co., Geo. M.... 83
Ohio Blower Co..... 79
Open Coil Heater & Purifier Co 95
Reliance Gauge Column Co.. 104
Schutte & Koerting Co.....102
Squires Co., C. E..... 96

Traps, Steam—*Continued.*
Steam Appliance Co..... 95
Watson & McDaniel Co.....105
Wright Mfg. Co..... 94

Traps, Vacuum
American Radiator Co..... 94
Open Coil Heater & Purifier Co. 95

Tube Cap Reseating Machines
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Tube Cleaners
Chesterton Co., A. W.....105
Garlock Packing Co..... 6
Johns-Manville Co., H. W.... 81
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7
Pierce Co., Wm. B.....2d cover
Robertson & Sons, Jas. L.... 73
Steam Appliance Co..... 95

Tube Cutters
Lagonda Mfg. Co.....3d cover

Tubing
National Tube Co..... 86

Turbines, Hydraulic
Allis-Chalmers Co.....110

Turbines, Steam
Allis-Chalmers Co.....110
General Electric Co.....115
Hooven, Owens, Rentschler Co. 117
Sturtevant Co., B. F.....111

Unions
Dart Mfg. Co., E. M..... 90
Jefferson Union Co..... 91
Lunkenheimer Co..... 4
National Tube Co..... 86

Valve Balls
Diamond Rubber Co..... 99

Valve Washers, Leather
Schieren Co., Chas. A.....106

Valves, Ammonia
Chapman Valve Mfg. Co..... 86
Monarch Valve & Mfg. Co.... 87
York Mfg. Co.....112

Valves, Angle
Homestead Valve Mfg. Co.... 86
Lunkenheimer Co..... 4
Monarch Valve & Mfg. Co.... 87
New Bedford Valve Mfg. Co.. 86

Valves, Back Pressure
Foster Engineering Co..... 86
Hughson Steam Specialty Co. 87
Jenkins Bros..... 69
Ruggles Co., Walter G..... 92

Valves, Blow-off
Homestead Valve Mfg. Co.... 86
Jenkins Bros..... 69
Liberty Mfg. Co..... 7
Lunkenheimer Co..... 4
Simplex Engineering Co..... 87
Ziermore Regulator Co..... 87

Valves, Check
Greene, Tweed & Co., 74 and 4th cover
Jenkins Bros..... 69
Lunkenheimer Co..... 4
Nelson Valve Co..... 85

Valves, Cylinder Relief
American Steam Gauge and Valve Mfg. Co.....64 and 65
Lunkenheimer Co..... 4

Valves, Disk
American Goetze-Gasket and Packing Co..... 76

Valves, Exhaust Relief
Allberger Condenser Co.....105
Jenkins Bros..... 69

Valves, Gate
Chapman Valve Mfg. Co..... 86
Detroit Lubricator Co..... 93
Greene, Tweed & Co., 74 and 4th cover
Jenkins Bros..... 69
Lunkenheimer Co..... 4
Nelson Valve Co..... 85
Ohio Brass Co..... 88
Pittsburgh Valve, Fdry. & Construction Co..... 86

Valves, Globe
Detroit Lubricator Co..... 93
Jenkins Bros..... 69
Lunkenheimer Co..... 4
Nelson Valve Co..... 85
New Bedford Valve Mfg. Co.. 86
Ohio Brass Co..... 88
Pittsburgh Valve, Fdry. and Construction Co..... 86

Valves, Piston
Baker Valve Co.....110

Valves, Pump
Garlock Packing Co..... 6
Jenkins Bros..... 69
New York Belting & Packing Co. 10
Peerless Rubber Mfg. Co..... 8

Valves, Regrinding
Lunkenheimer Co..... 4
Nelson Valve Co..... 85

Valves, Return Stop
Lagonda Mfg. Co.....3d cover

Valves, Safety
American Steam Gauge and Valve Mfg. Co.....64 and 65
Ashton Valve Co..... 89
Crosby Steam Gage & Valve Co. 88
Detroit Lubricator Co..... 93
Jenkins Bros..... 69
Lunkenheimer Co..... 4
Pittsburgh Valve, Fdry. and Construction Co..... 86

Valves, Safety Stop
Foster Engineering Co..... 86

Valves, Stop Check
Jenkins Bros..... 69
Lagonda Mfg. Co..... 3d cover
Schutte & Koerting Co.....102

Valves, Superheated Steam
Chapman Valve Mfg. Co..... 86
Lunkenheimer Co..... 4
Nelson Valve Co..... 85

Valves, Tank
Nelson Valve Co..... 85

Valves, Throttle
Detroit Lubricator Co..... 93

Valves, Trip Throttle
Schutte & Koerting Co.....102

Ventilators
Burt Mfg. Co..... 16
Ohio Blower Co..... 79
Schutte & Koerting Co.....102
Turbo-Blower Co.....102
Wing Mfg. Co., L. J..... 78

Vises
Armstrong Mfg. Co..... 90
Williams & Co., J. H..... 74

Water Columns
American Steam Gauge and Valve Mfg. Co.....64 and 65
Huyette Co., P. B..... 89
Lunkenheimer Co..... 4
Reliance Gauge Column Co...104
Robertson & Sons, Jas. L.... 73
Wright Mfg. Co..... 94

Water Weighers
Willcox Engineering Co..... 100

Welding Apparatus
Alton, Laine & Co..... 97

Whistles
American Steam Gauge and Valve Mfg. Co.....64 and 65
Lunkenheimer Co..... 4

Wrenches, Nut and Bolt
Trimont Mfg. Co..... 92

Wrenches, Pipe
Trimont Mfg. Co..... 92
Williams & Co., J. H..... 74